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A STUDY OF SPOTTED OWL HOME-RANGE SIZE AND COMPOSITION IN THE SIERRA NATIONAL FOREST

by

Donald L. Neal, Jared Verner, George N. Steger, and Gary P. Eberlein

Pacific Southwest Forest and Range Experiment Station
Fresno, California

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INTRODUCTION

This report summarizes key activities and results of field studies of spotted owls in the Sierra and Sequoia National Forests during 1989, frequently relating them to comparable results from 1987 and 1988. Current plans call for shifting research emphasis during the summer of 1990, when we will initiate two domographic studies--one in our current study area in the Sierra National Forest and one in Sequoia National Park. This will allow comparisons between spotted owl demographics in a managed National Forest and protected forests of the National Park. This departs from plans reported in our Annual Report for 1988 (Neal et al., 30 January 1989) and reflects new interest in the effects of complete protection and various selective logging practices on spotted owls.

OBJECTIVES

The principal objectives of spotted owl research being done by the Pacific Southwest Forest and Range Experiment Station (PSW) work unit in Fresno, California are to:

1. Determine the sizes and extent of overlap of home ranges of pairs of radio-tagged spotted owls during the breeding season, and characterize the structure and composition of vegetation included within their home ranges.
2. Determine the timing and extent of altitudinal migration exhibited by radio-tagged spotted owls.
3. Determine the sizes and extent of overlap of home ranges of individual spotted owls during the nonbreeding period, and characterize the structure and composition of vegetation included with the home ranges.
4. Determine breeding activity, monitor breeding success, and color-band all offspring produced.
5. Characterize diets from collections of cast pellets.

STUDY AREA

The study area is located about 45 miles (72 km) northeast of Fresno, California, within the Sierra and Seqouia National Forests, in the watersheds of the San Joaquin and Kings Rivers. Vegetation in the higher elevation spotted owl home ranges, occurring between 5000 and 8000 ft (1525-2440 m), is described as mixed-conifer forest, dominated by white fir (Abies concolor), Jeffrey pine (Pinus jeffreyi), incense cedar (Calocedrus decurrens), red fir (A. magnifica), and sugar pine (P. lambertiana). Nearly all of this zone was logged between 1880 and 1930 and most of the trees remaining today were of unmerchantable size or species at that time. Only small, scattered patches of old-growth remain. Timber harvest has continued on National Forest land and private holdings at a much reduced rate since 1930. Forest regeneration programs are in place on both public and private lands. Nearly all logging has been some form of selective cutting and the little clear-cutting that has taken place has been in scattered patches of generally less than 20 acres.

Home ranges at intermediate elevations, between 3000 and 5000 ft (900-1525 m), are also in mixed-conifer forests, but these are dominated by ponderosa pine (P. ponderosa), white fir, incense cedar, and black oak (Quercus kelloggi).

Home ranges at low elevations, between 1000 and 3000 ft (300-900 m), are in habitats characterized by oak-woodland vegetation dominated by blue oak (Q. douglasii), live oak (Q. wislizenii), digger pine (P. sabiniana), and various foothill chaparral species.

METHODS

Capture

During 1987 and 1988, capture effort was concentrated on maintaining a cluster of radio-equipped birds from pairs thought to have adjacent or overlapping home ranges. As reported last year (1988 Annual Report, Neal et al., 30 January 1989) recapturing birds with nonworking transmitters continued to be difficult. Roost sites remained high in trees, making it difficult to bait birds down for capture. Fish landing nets, mist nets, noose poles, and traps were all tried. Mist nets were more successful in 1989 than in the past. No injuries to birds or personnel occurred during capture operations in 1989.

Radio-locating birds

We continued to use Telonics Model TR-2 receivers and Telonics Model 70 and the AVM P2 transmitters. However, several of the Telonics Model 70s were rebuilt and modified to reduce output power and extend life from 10 to 18 months. The performance loss has not presented major problems and the extended operating life will significantly reduce the recapture workload.

Radio-locating and data processing were done as in 1988.

Diet

The collection of cast pellets continued as in previous years and approximately 500 pellets have been collected. No diet analysis from pellets collected in 1989 was done because of a lack of experienced personnel. Collections in 1989 were concentrated in the periods and areas where previous samples were the smallest--in coniferous forest in winter and oak woodland in summer.

Habitat descriptions

As in 1987 and 1988, each seasonal home range was delineated using the minimum convex polygon method (MCP) and divided into habitat-type polygons using aerial photos and ground checks. All mapping of home ranges has been completed. Maps have been digitized using the D-WRIS system. Combining output from this system with radio-location data, using the UTM mapping system, allows observations to be assigned to the correct habitat polygon. This provides the data for habitat-use analysis (chi-square tests) without long hours of hand counting of observations by polygon.

On-the-ground transect measurements of components of each polygon were begun for the coniferous-forest home ranges during the summer of 1989. These measurements, and comparable ones in the oak-woodland habitats, will be completed in 1990. Data for both study areas will also be analyzed in 1990 and summarized in our annual report for that year.

The seven habitat types used in a previous analysis of habitat selection (see Annual Report for 1988, 30 January 1989) have been combined into three types. Meadow, shrub fields, rock outcrop, and shrub/rock types were combined with the low-density coniferous forest type (0-39% canopy cover--see brief descriptions of the habitat types in our report for 1988). Polygons of all of these habitat types had a low canopy closure of coniferous trees so can legitimately be included in this type. This strengthens the analysis by increasing the number of polygons in the low-density classification.

RESULTS

Capture

Twenty-four birds were radio-monitored during 1989, 12 from previous captures and 12 new captures (Figure 1). The most significant finding of the 1989 work was the confirmation of year-long occupancy and breeding by spotted owls in oak-woodland habitats in the western foothills of the Sierra Nevada. Our foothill study area was located near the east end of Pine Flat Reservoir, at elevations ranging from about 1000 feet to 3000 feet. We have not yet given equal attention the transitional habitats between 3000 and 5000 feet in elevation. We suspect this mosaic of habitat types also supports a spotted owl population.

In the winter of 1987, three individual birds migrated to the oak-woodland type, leaving their mates in the coniferous forest habitat. While tracking one of these birds in the oak woodland, a pair of spotted owls was found. The behavior of this pair seemed to indicate that they had an established territory and might be using this low-elevation site all year. The birds were captured and radio-equipped. In the spring, after all migrant birds had returned to the coniferous forest, we were able to confirm year-round use of a foothill home range by this pair.

A small drainage with a narrow riparian strip of deciduous hardwood trees seemed to be the principal characteristic of the core area used by these birds. Eighteen similar areas were located in the vicinity between elevations of 1200 and 2800 feet (550-850 m). Fifteen of these sites were visited and called for owls one to four times. Responses were obtained in nine (60%) of the sites and members of five pairs of owls were captured and radio-equipped in the spring and summer of 1989.

Breeding

The first documented breeding efforts during our study occurred in 1989. Of 15 pairs monitored during the summer, seven bred and fledged nine young. Among the nine pairs monitored in coniferous forest during the breeding season, three (33%) bred. Three of the six pairs (50%) monitored in the oak-woodland bred successfully in 1989.

Radio locations

Twenty-four individual owls were monitored with operating radio transmitters for various periods totaling 130 bird-months, during the 9-month period from 1 January through 30 September 30 1989. A total of 1589 verified, usable radio locations were obtained and mapped (an average of 12 locations per bird month).

Receivers and most transmitters performed satisfactorily in 1989. The shift to locally unused frequencies assigned to Forest Service communications has not been a problem other than limiting the number of available frequencies. This required equipping more than one bird with transmitters on the same frequency. In these instances, we were able to distinguish between birds with the same frequencies because they had different pulse rates and/or pulse characteristics.

Seasonal variation in home-range occupancy

In our report for 1988, four types of winter behavior were described in relation to seasonal movements and home-range occupancy: (1) permanent residents, (2) enlargers, (3) shifters, and (4) migrators. These all apply to birds using the coniferous forest habitats. For 1989 it is necessary to add another classification: (5) oak-woodland permanent residents.

Among the 13 birds monitored in the coniferous forest in the summer of 1989, two were enlargers, two were migrants, one was a shifter, five were residents, and the behavior of three was undetermined. Of the 12 birds using the

oak-woodland in the summer, 11 were permanent residents and one was undetermined (Table 1).

The mean elevation of all locations of all birds using the coniferous forest all year was 6152 feet (1875 m) during the summer and 5932 feet (1808 m) during the winter. Birds classified as enlargers and shifters enlarged their home ranges and shifted there activities toward slightly lower elevations.

One migrator, the Stevenson Female (Figure 2), migrated to her winter range in the oak woodland, a straight-line distance of 15 mi (24.0 km), between 8 and 11 November 1988. She moved back up to her coniferous-forest summer range between 28 March and 17 April 1989. The mean elevation of her summer locations (n = 53) was 6742 feet (2054.9 m) and the mean elevation of her winter range locations (n = 71) was 1066 feet (325 m). The Strawberry Female moved to her winter range between 2 and 15 December 1988 and returned to the coniferous forest between 1 and 7 March 1989 (Figure 2). The straight-line distance of her migration was 12 miles (19 km). Mean elevations for her summer and winter ranges were 5614 feet (1711 m) (n = 29) and 2269.0 feet (692 m) (n = 28), respectively.

Home-range size

Again in 1989, the MCP method was used to calculate home-range size (Figure 3). However, we have included examples of the Adaptive Kernel (AK) method of calculating home ranges, at levels 50% through 95% (i.e., delineating the smallest home range possible by using 50% of all locations, and the smallest one possible by including 95% of all locations) (Figure 4-14). This method appears to provide a more meaningful method of estimating home-range size and emphasizes those areas that seem to have the greatest importance as determined by owl use.

Home-range sizes were similar to those reported in 1987 and 1988. Pair summer home ranges in the coniferous forest, for all three years, averaged 3379 acres (1367 ha) using the MCP method. Summer home ranges of birds permanently resident in the oak woodlands averaged 766 acres (310 ha) (Table 2). Winter home ranges for individual birds in the coniferous forest averaged 3507 acres (1419 ha). We were unable to determine winter pair home-range sizes, because members of the coniferous-forest pairs moved independently of each other, and often did not share areas of use. An extreme example was the Strawberry Pair, in which the female move to oak-woodland habitat while the male remained in the coniferous-forest type. For birds that migrated from the coniferous-forest zone to the oak woodlands, winter home ranges averaged 412 acres (167 ha).

Mortalities

Three adult mortalities occurred between 1 January and 30 September 1989, and two fledgling owls were not seen again shortly after leaving the nest. We were unable to positively determine the cause of mortality in any instance.

Two adult females in the oak woodlands died in mid-summer. The Linda Creek Female died shortly after fledging two young. Her mate and two young moved down-slope to the east end of their home range, where one of the young disappeared. The Sycamore Female, a nonreproductive bird also died in mid-summer. After the her death, her mate moved southwest and downslope, intruding on the west end of the Kirch Flat pair's home range. Soon after this movement, a large wildfire burned the extreme north edge of the Sycamore home-range. The Sycamore Male has since returned to his normal movement patterns. One of two chicks produced by the Kirch Flat pair, disappeared about mid-summer, shortly after fledging. The only coniferous-forest owl to die was the Providence Female; she died in September after fledging two young.

In the 3 years of study, we have radio equipped 33 individual birds; nine of those have died (Figure 1). Five of the deaths occurred within 40 days after

attaching transmitters for the first time or attaching replacement transmitters (Table 3). Yet, seven birds have been carrying radio transmitters over 780 days with no known problem. We do not have enough information to conclude that these birds died from stress related to handling or to improperly attached transmitters.

Diet

Over 300 cast pellets have been collected since 1 January 1989. Due to lack of personnel, none of this year's collection has been examined. Therefore, we have no new diet information to report.

Habitat descriptions

Spotted owl home ranges, as determined by the MPC method, have been divided into three canopy-closure classes: (1) 70%+; (2) 40-69%; and (3) 0-39%. The average home-range composition of the four pairs using the coniferous forest, with adequate data for classification was 11.5% in 70%+ canopy closure, 67.1% in 40-69% canopy closure, and 21.5% in 0-39% canopy closure (Table 6). That of the five pairs in the oak-woodland type was 20.0% in 70%+ canopy closure, 58.9% in 40-69% canopy closure, and 21.1% in 0-39% canopy closure (Table 10). Data are also presented for individual birds in Tables 7, 8, 9, and 11.

The number of observations in each of these types was compared to the number expected based on the proportion of the home-range in each canopy class (Tables 4, 5, 6, and 11). As in past years, the birds showed a significant (chi-square) overutilization of the 70%+ canopy-closure class by using it about twice as often as expected. Their use of the 40% to 69% canopy-closure areas was as expected. And their use of the low-density stands (0% to 39% canopy closure) was significantly less than expected in all cases (Tables 4-11, and Figures 15 and 16). Results from the coniferous forest (Tables 4-9) and the oak woodland (Tables 10-11) were remarkably similar.

Maps showing the distribution of canopy-cover classes and bird locations are provided in Figures 17 through 20 for the coniferous-forest type and in Figures 21 through 25 for the oak-woodland type.

DISCUSSION

Breeding owls in oak woodlands

Discovery of a substantial number of breeding pairs in foothill oak woodlands of the Sierra Nevada has important implications for the maintenance of a viable population of spotted owls in this portion of the species' range. If this situation prevails throughout most or all of the Sierran foothills, it would substantially widen the distribution of the species in the Sierra Nevada, increasing the likelihood that dispersing juveniles would be able to locate suitable breeding territories. The matter warrants continued study to learn how widespread foothill breeding by spotted owls is.

Attributes of suitable owl habitat

The repeated pattern of significant overuse of high-density stands and underuse of low-density stands makes a compelling case that this is a real and significant aspect of the biology of spotted owls in the Sierra Nevada. It repeats a pattern found in many other studies of the species in other parts of its range. We believe that our results indicate that suitable owl habitat in the Sierra Nevada must provide canopy cover of at least 40% and that a substantial proportion of a pair's home range needs to provide canopy cover in excess of 70%.

Home-range size

In the conifer-forest zone of the Sierra Nevada, our results for the past three years indicate that spotted owls generally use areas averaging about 3400 acres, including about 460 acres in stands with 70% or greater canopy cover, and about 1990 acres in stands with 40% to 69% canopy cover. Assuming that these two stand types identify suitable habitat for spotted owls in the Sierra Nevada, the total is 2550 acres--considerably more than the 1000 acres currently specified in Region 5 standards for SOHAs, even counting the "replacement" acres. This matter needs to be addressed by Regional guides, as a part of adaptive management for spotted owls.

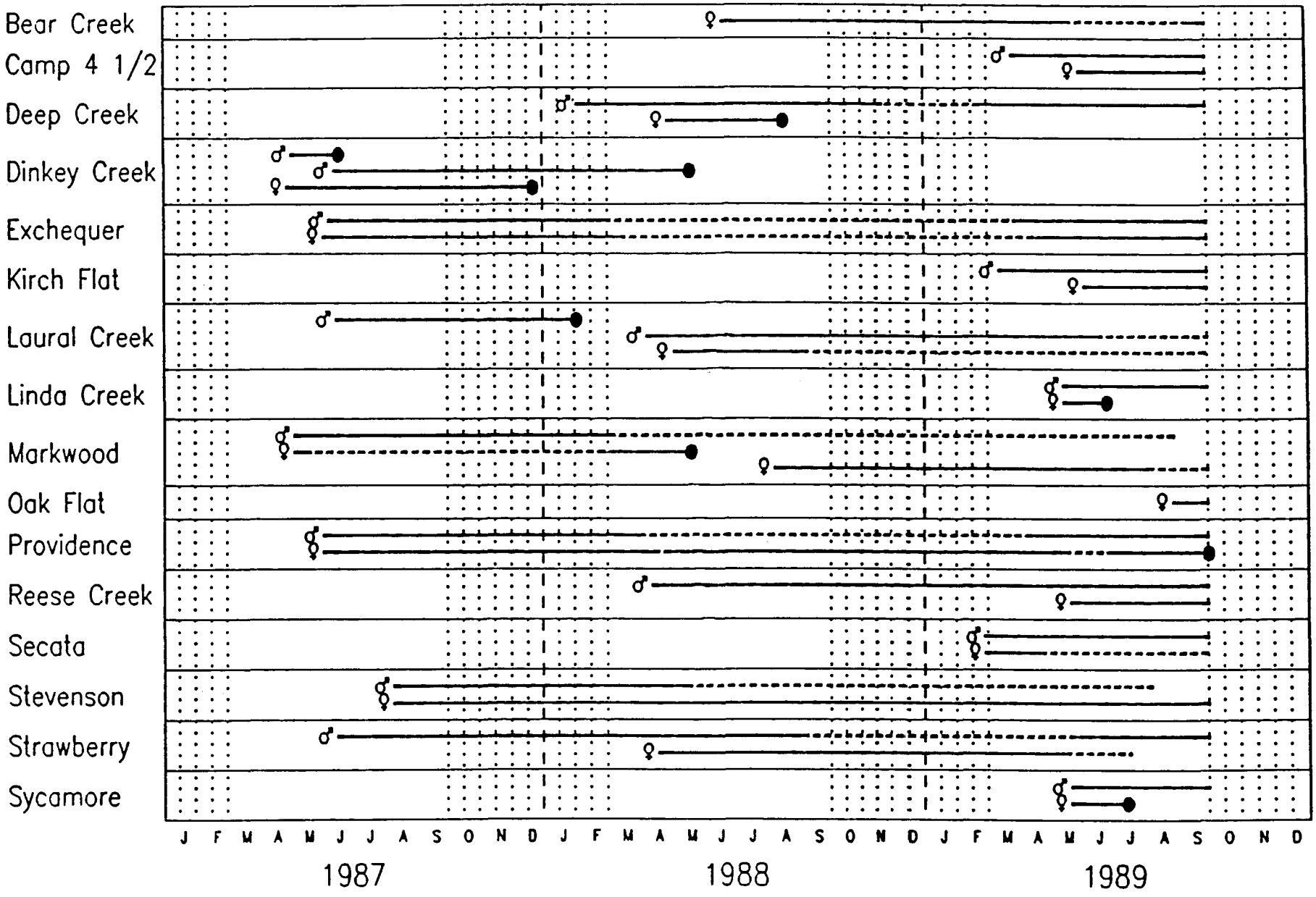


Figure 1. Periods spotted owls were equipped with radios. Solid bars indicate periods that transmitters were operating and successful monitoring was taking place. Dots indicate death of a bird. Shaded periods represent periods not included the the summer data.

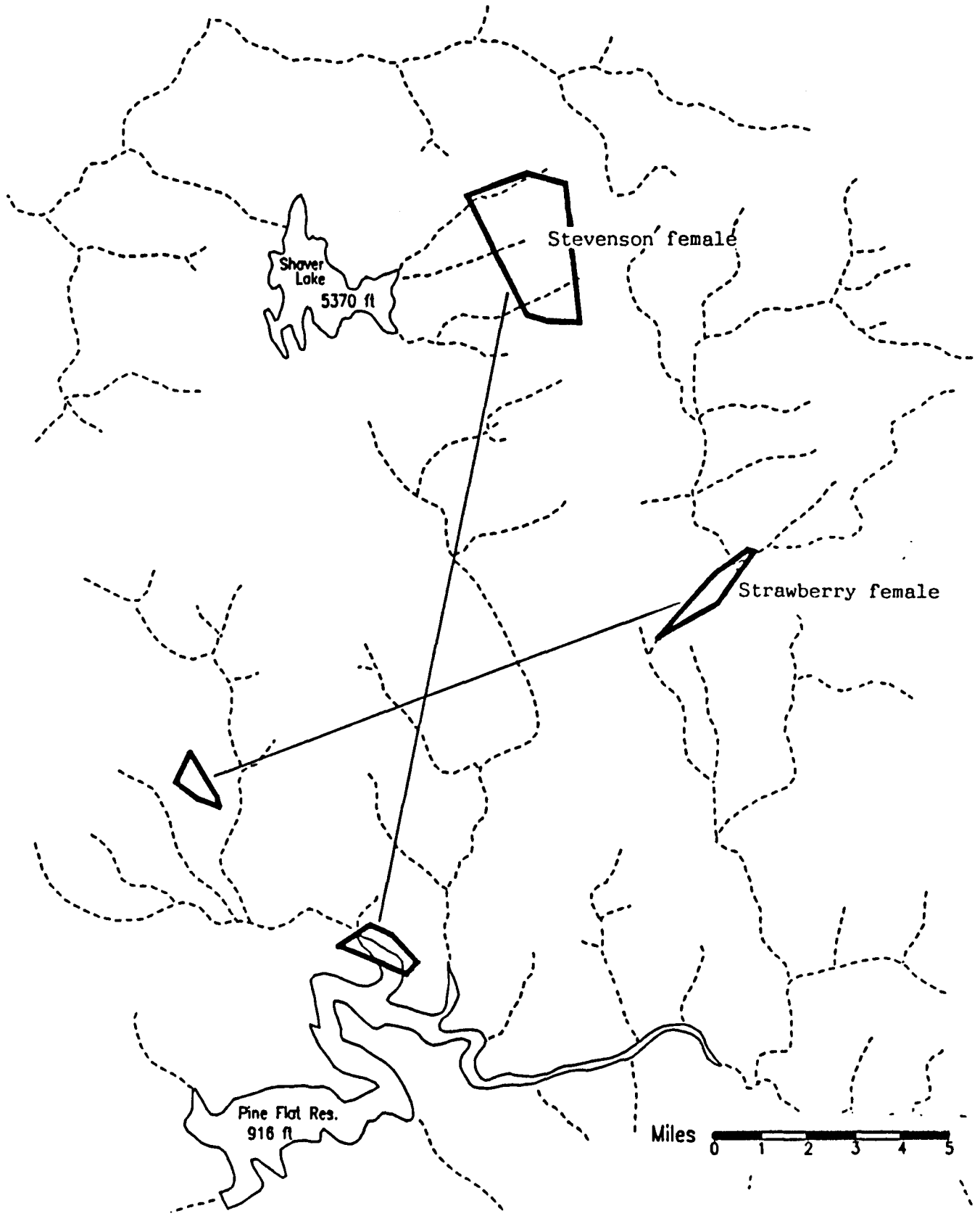


Figure 2. Summer and winter home ranges and approximate migration routes of the Strawberry and Stevenson females, the only birds to migrate in 1989.

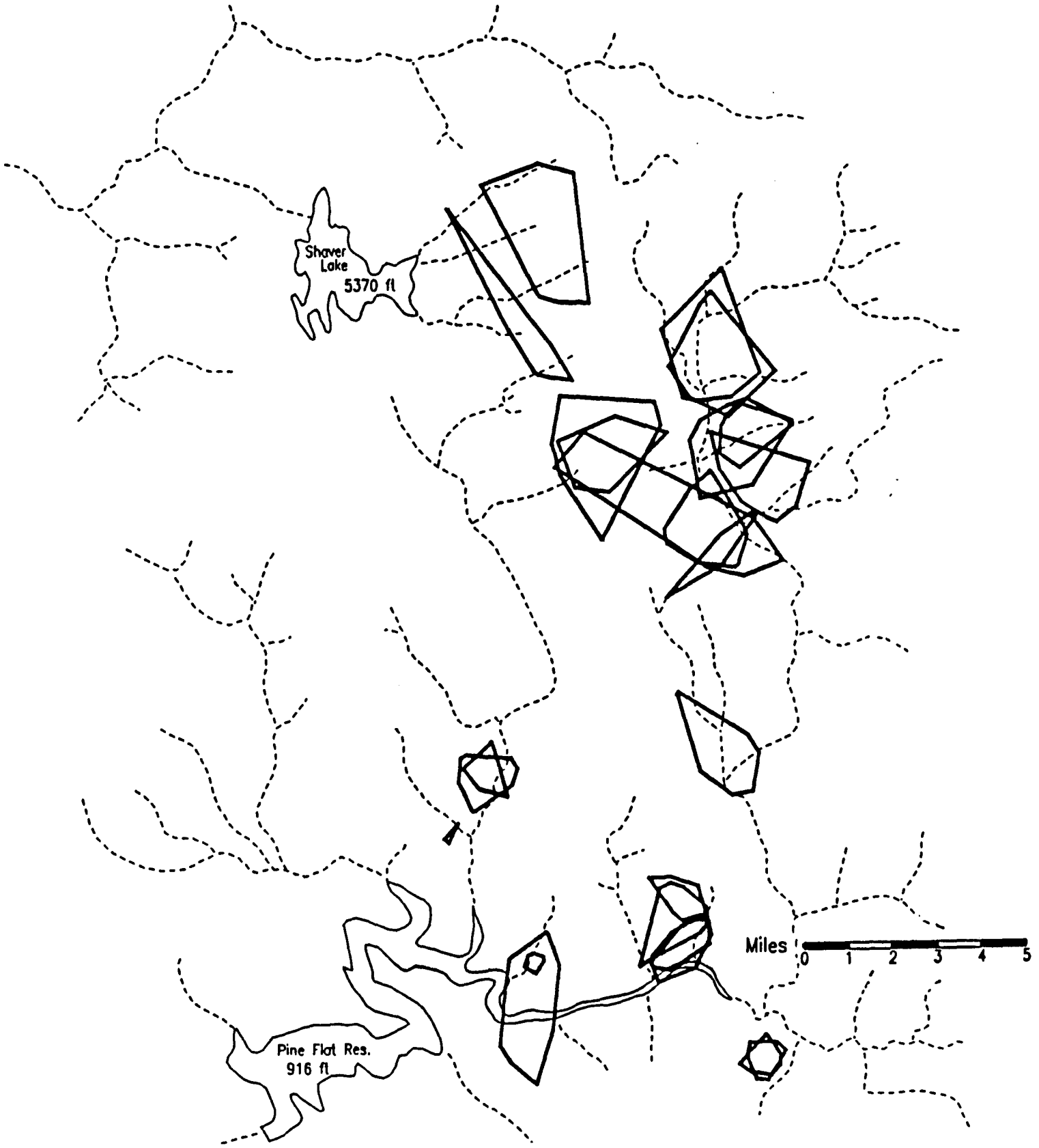


Figure 3. Home ranges of pairs of spotted owls monitored in 1989 in the Sierra and Sequoia National Forests.

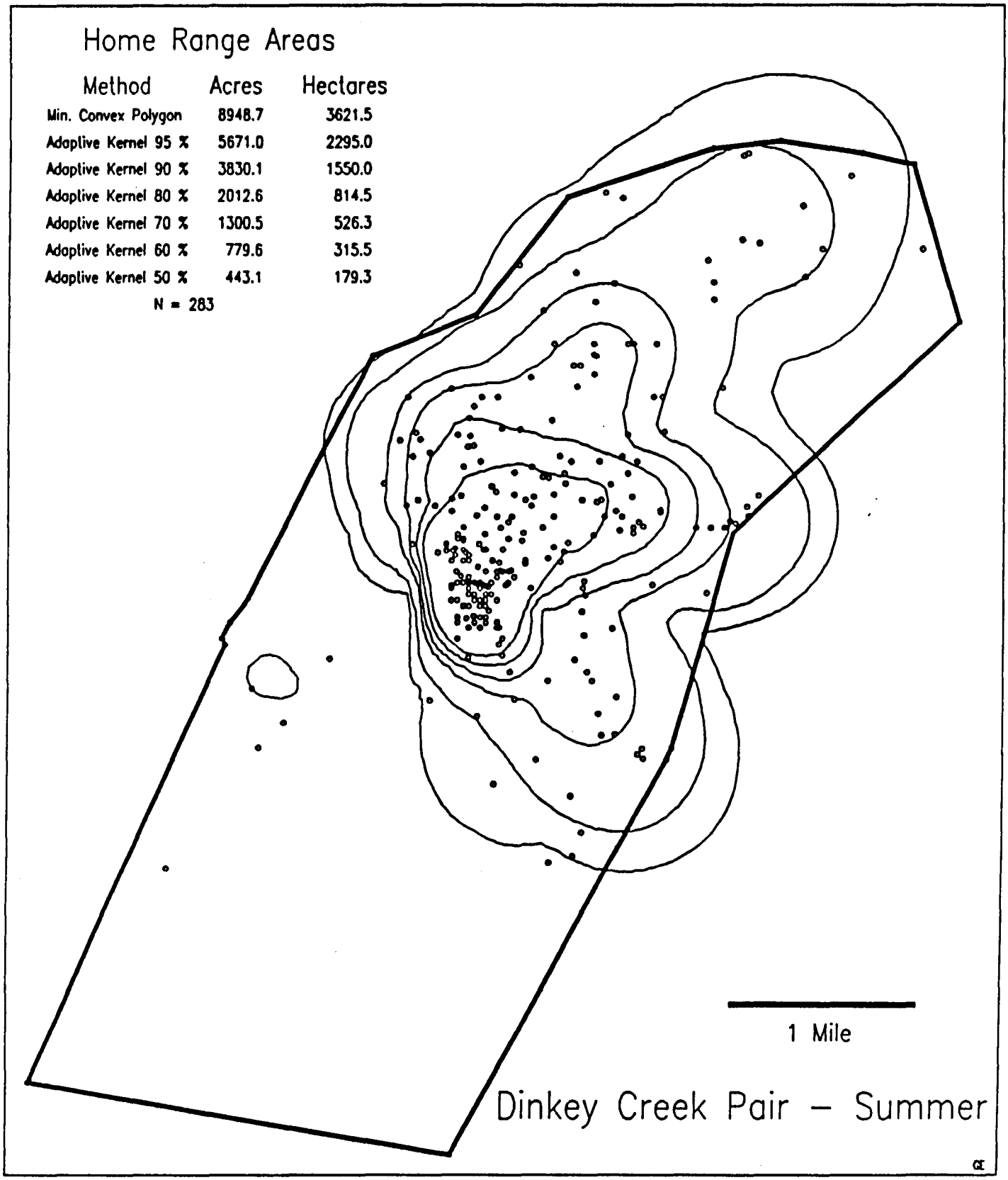


Figure 4. Distribution of radio locations for the Dinkey Creek pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

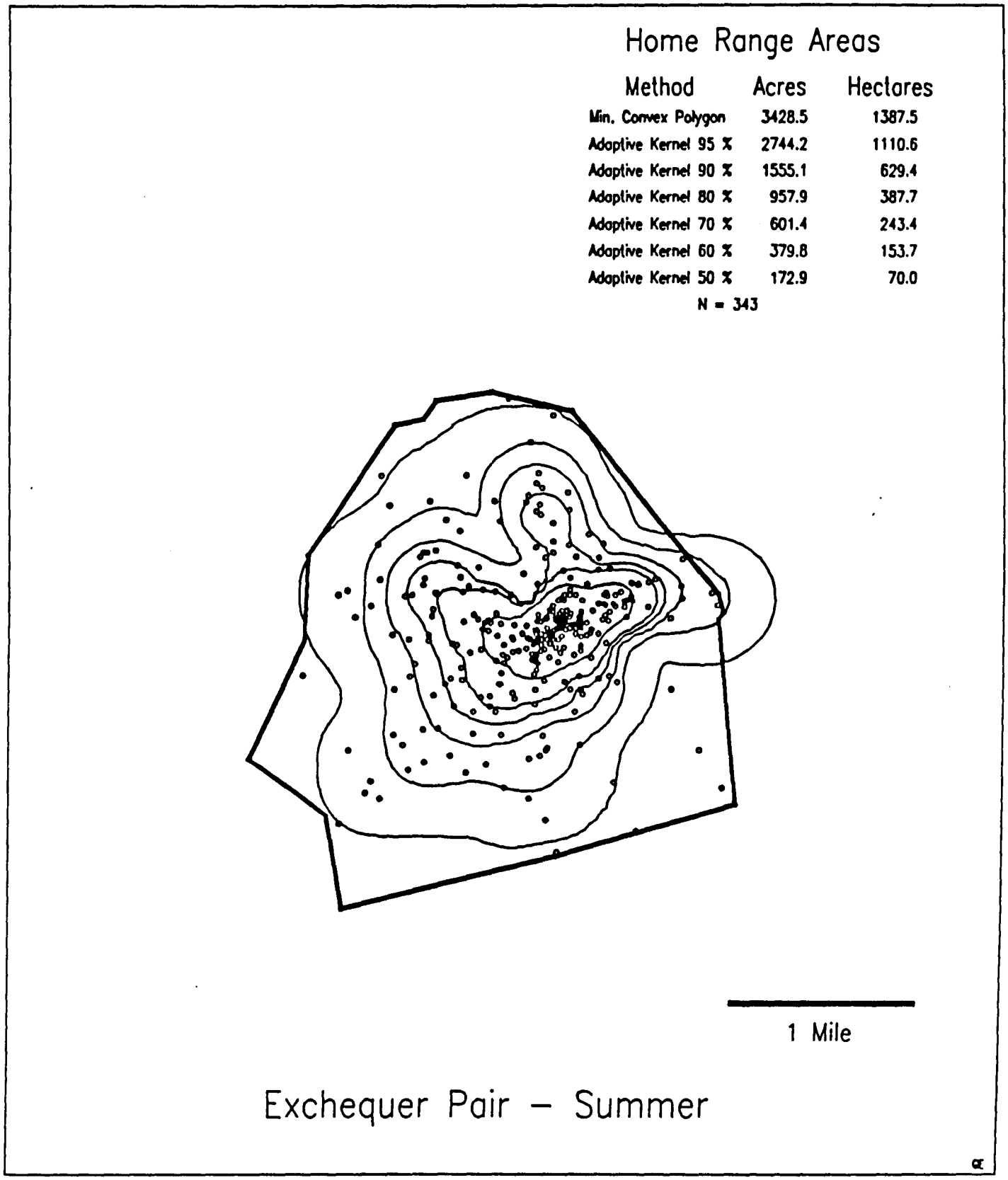


Figure 5. Distribution of radio locations for the Exchequer pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

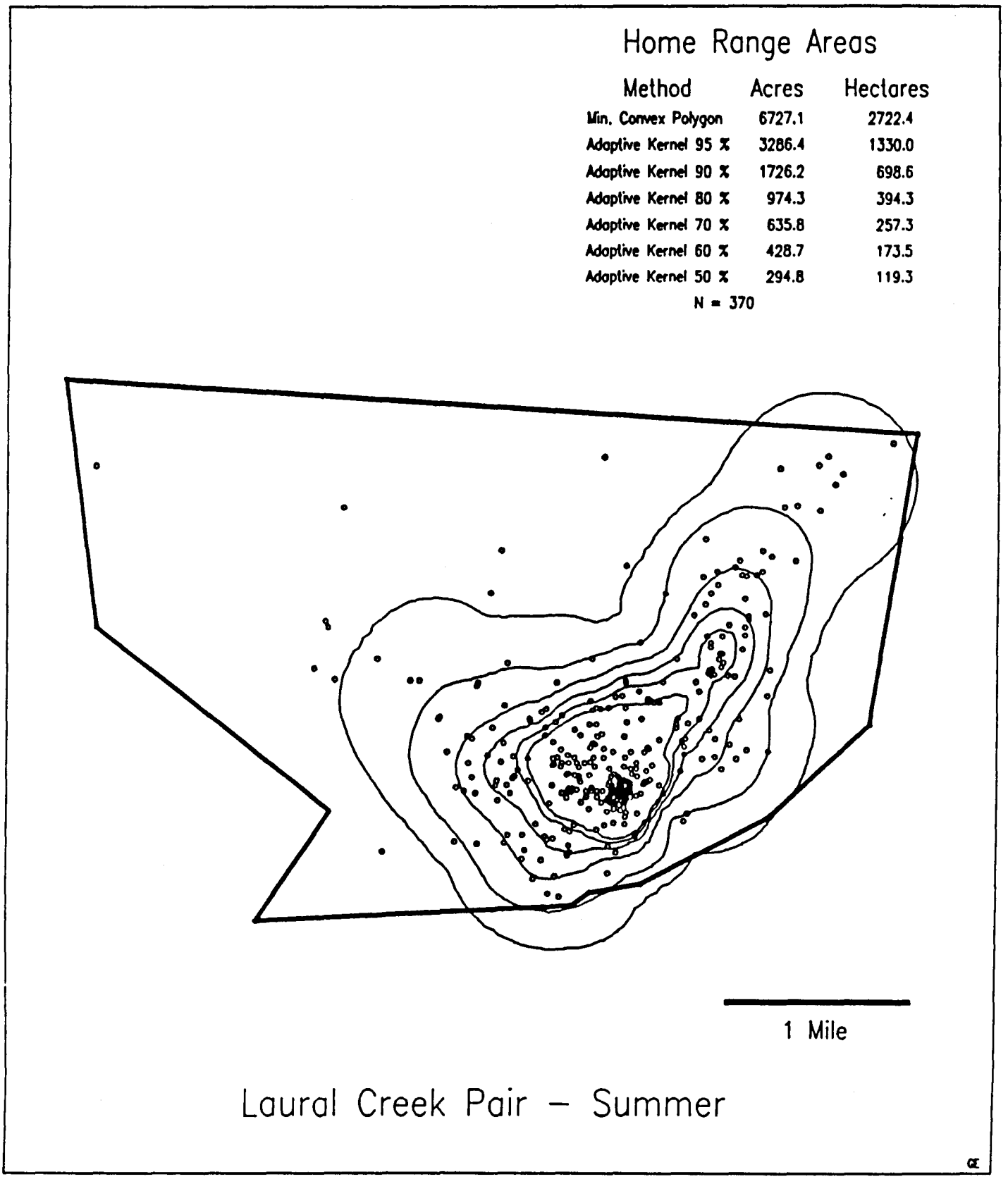


Figure 6. Distribution of radio locations for the Laural Creek pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

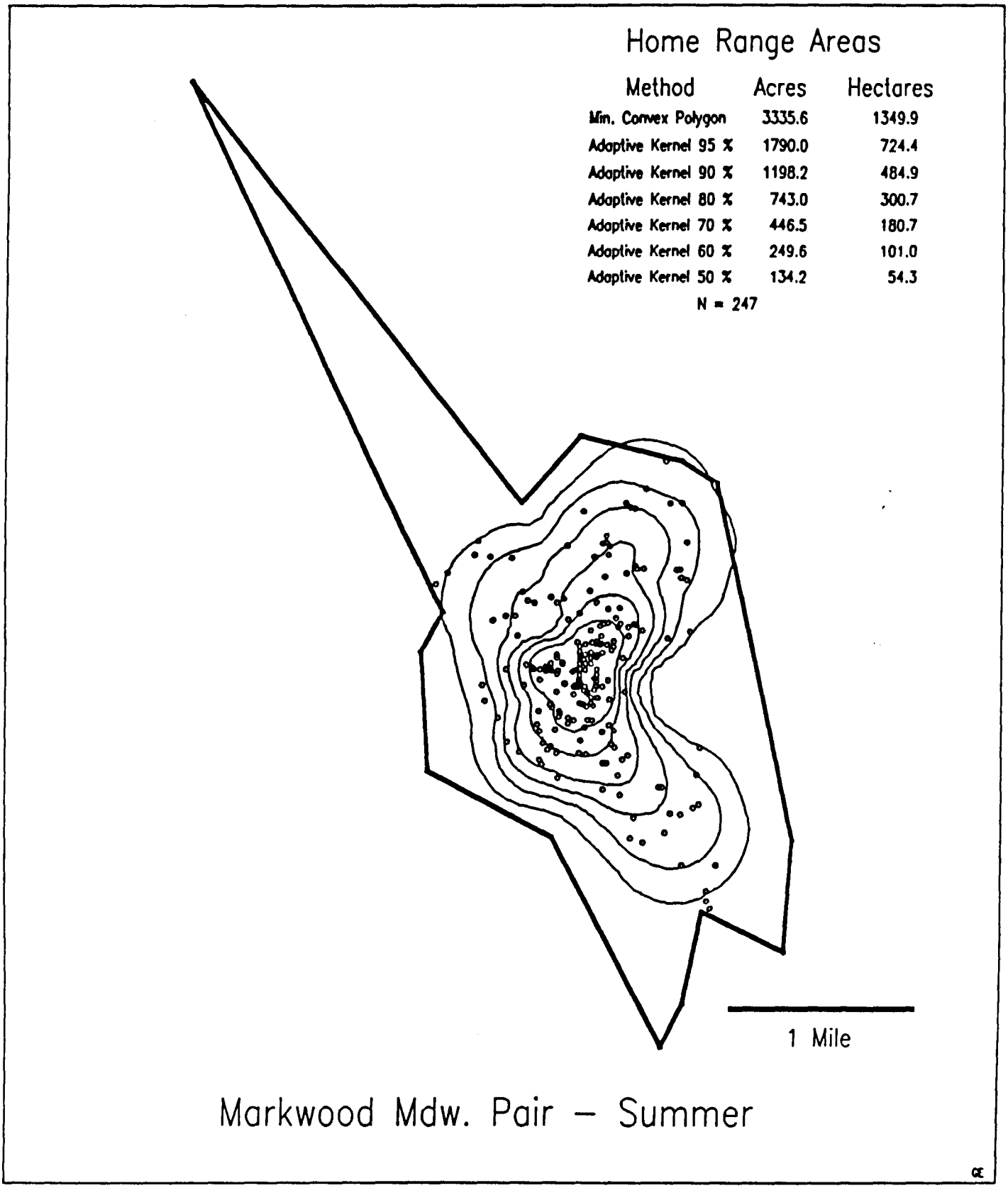


Figure 7. Distribution of radio locations for the Markwood Meadow pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

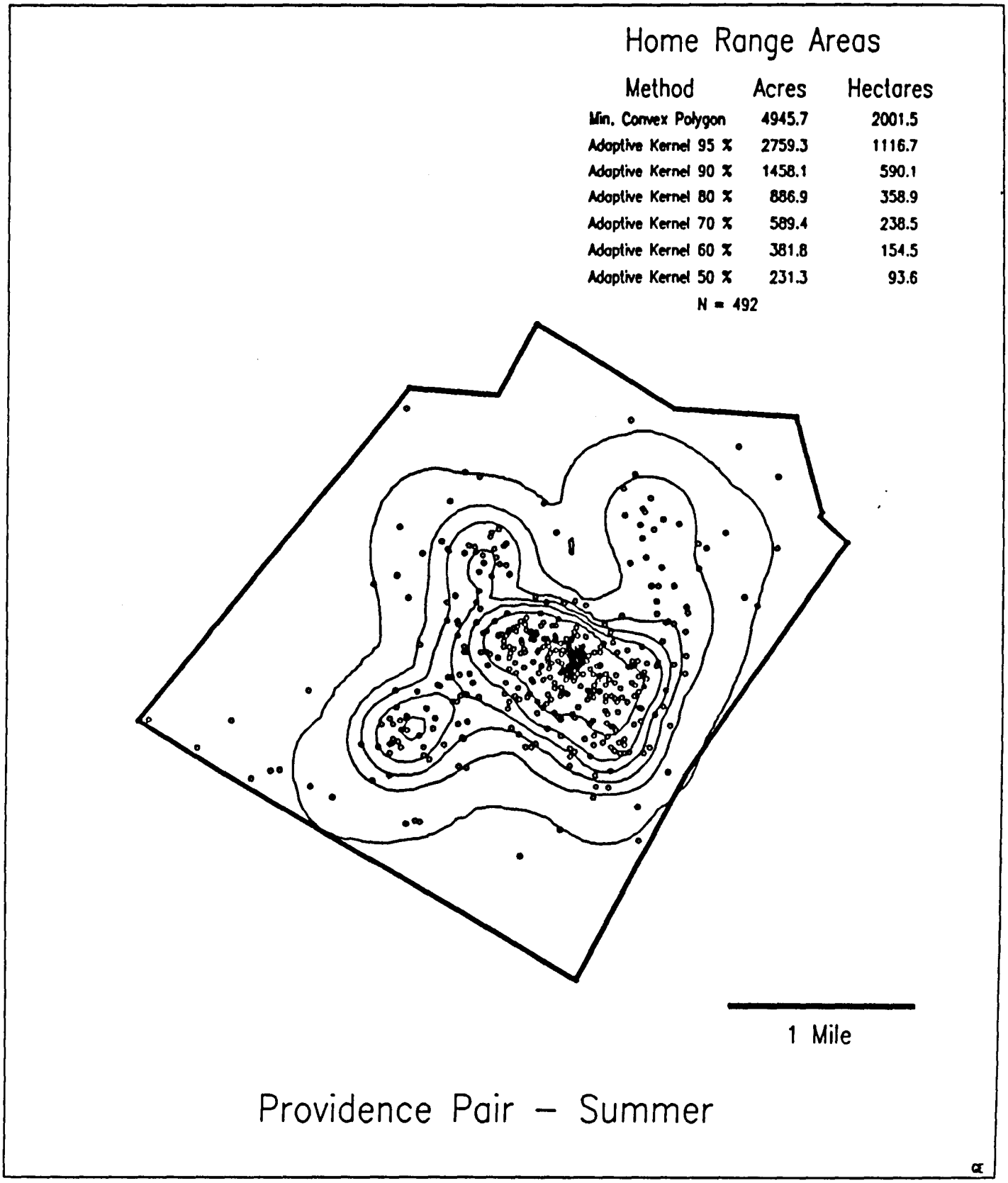


Figure 8. Distribution of radio locations for the Providence Creek pair with the minimum convex polygon and adaptive kernel methods of delineating home-range.

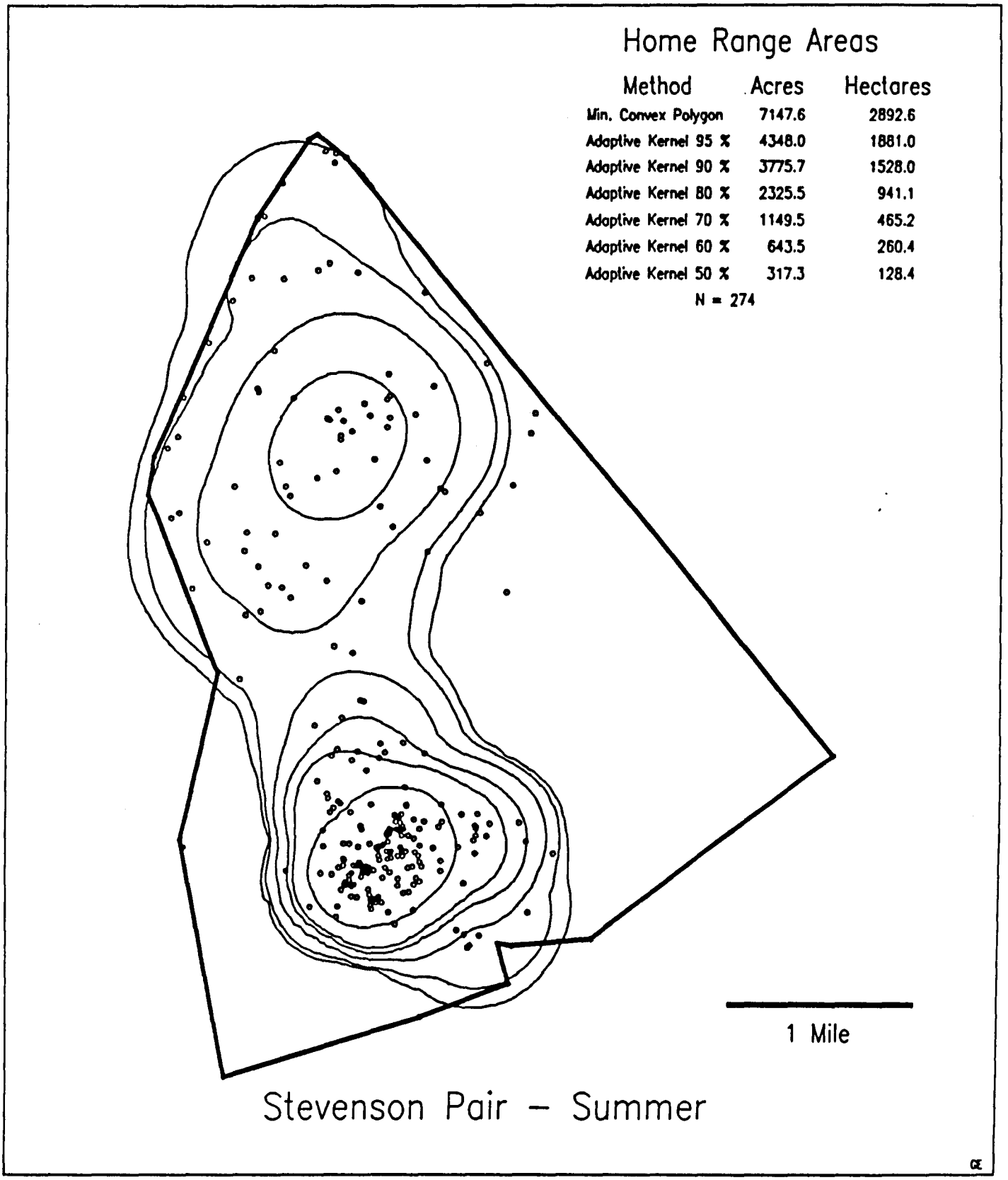


Figure 9. Distribution of radio locations for the Stevenson pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

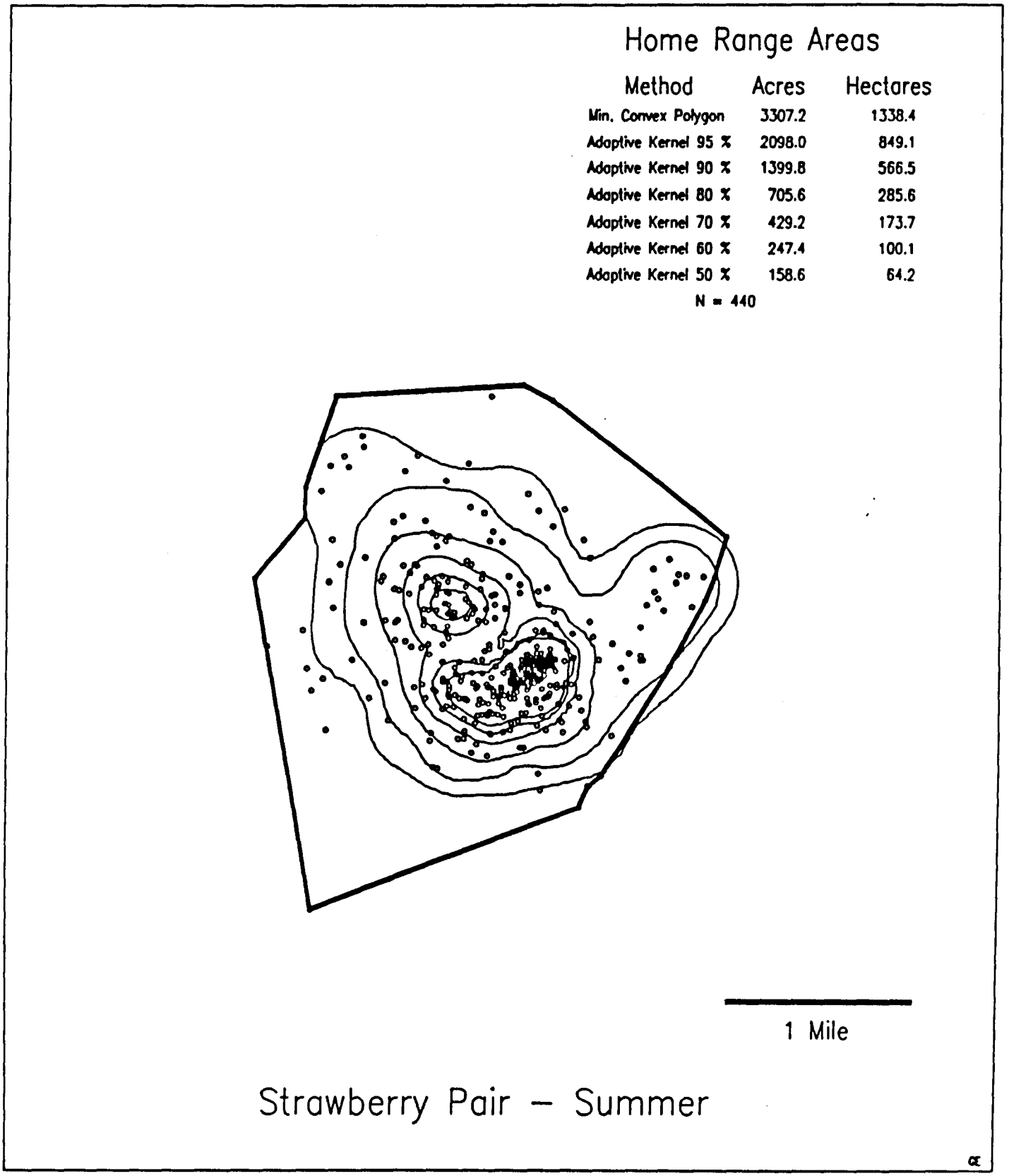


Figure 10. Distribution of radio locations for the Strawberry pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

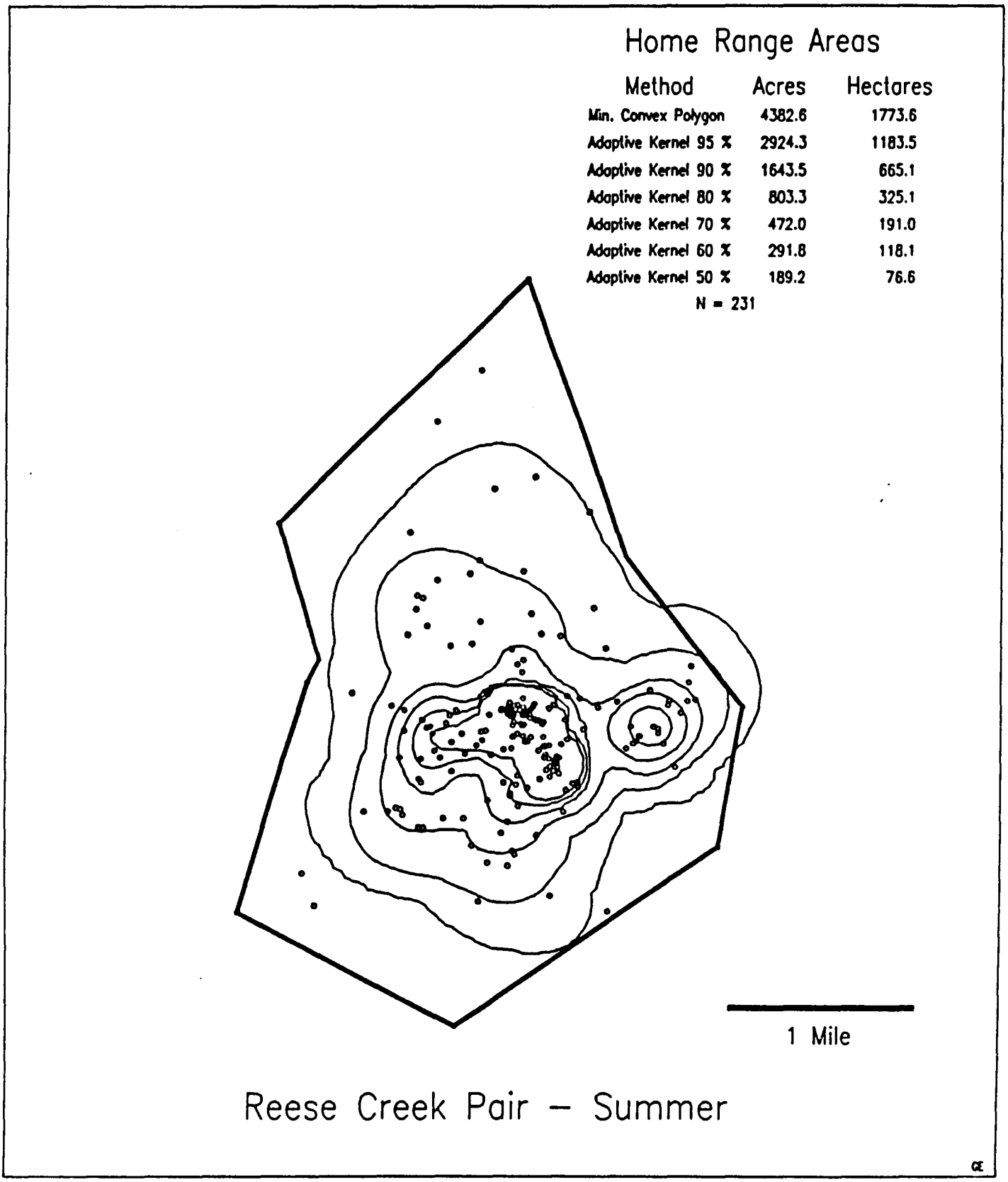
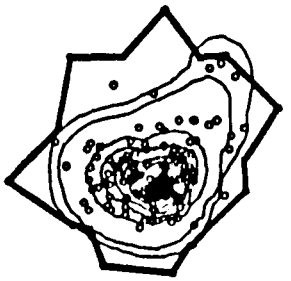


Figure 11. Distribution of radio locations for the Reese Creek pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

Home Range Areas

Method	Acres	Hectares
Min. Convex Polygon	402.8	163.0
Adaptive Kernel 95 %	288.1	116.6
Adaptive Kernel 90 %	209.1	84.6
Adaptive Kernel 80 %	88.7	35.9
Adaptive Kernel 70 %	55.4	22.4
Adaptive Kernel 60 %	32.9	13.3
Adaptive Kernel 50 %	20.2	8.2

N = 210



1 Mile

Camp 4 1/2 Pair – Summer

Figure 12. Distribution of radio locations for the Camp 4-1/2 pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

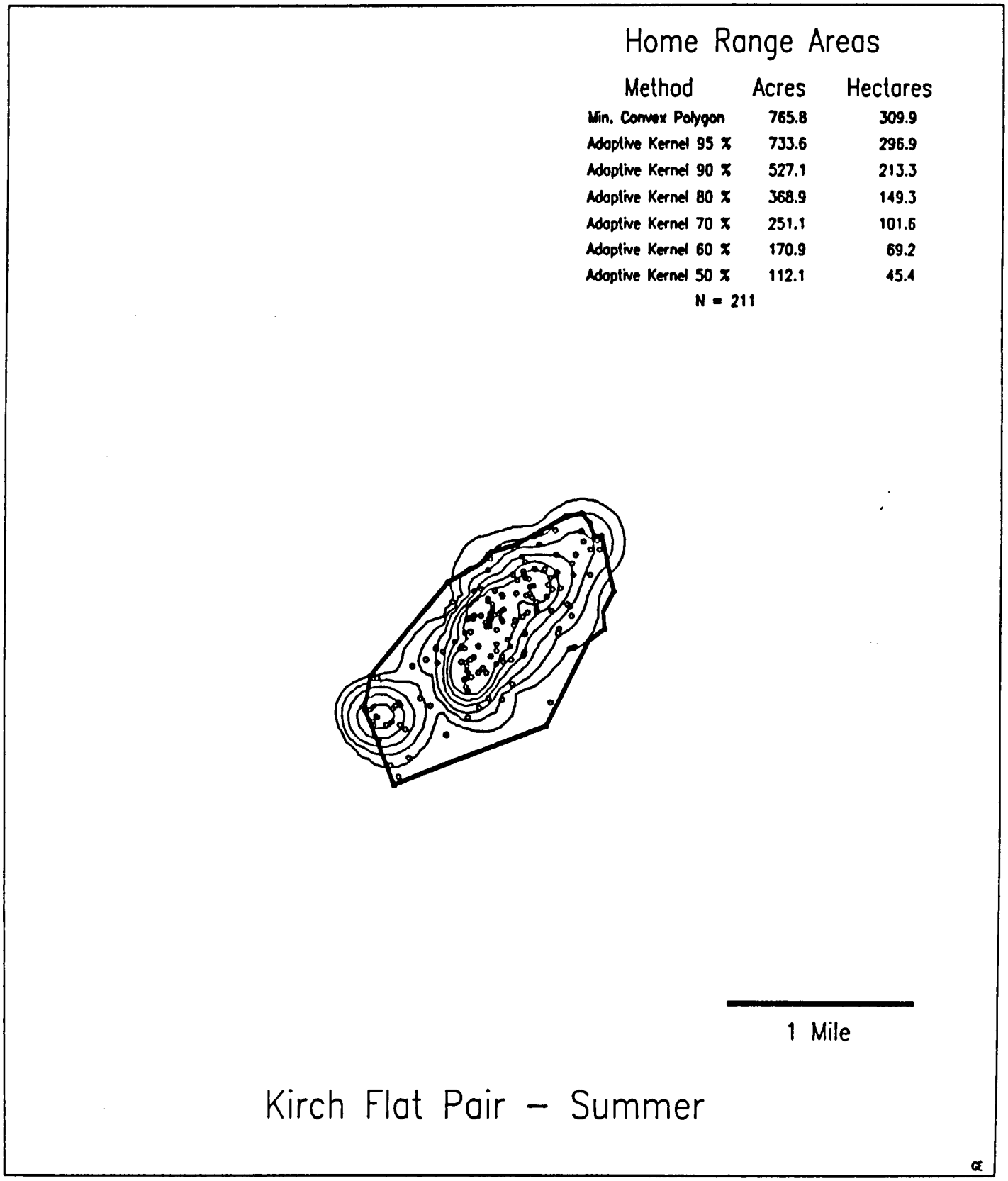
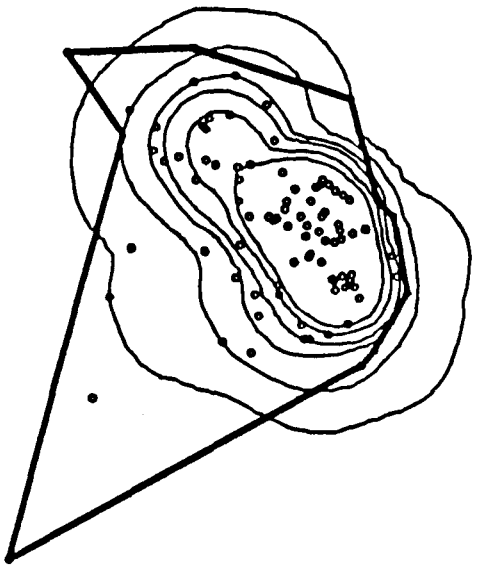


Figure 13. Distribution of radio locations for the Kirch Flat pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

Home Range Areas

Method	Acres	Hectares
Min. Convex Polygon	1157.4	468.4
Adaptive Kernel 95 %	1204.9	487.6
Adaptive Kernel 90 %	672.6	272.2
Adaptive Kernel 80 %	446.0	180.5
Adaptive Kernel 70 %	361.5	146.3
Adaptive Kernel 60 %	261.9	106.0
Adaptive Kernel 50 %	176.8	71.6

N = 99



1 Mile

Sycamore Creek Pair – Summer

Figure 14. Distribution of radio locations for the Sycamore Creek pair of birds with the minimum convex polygon and adaptive kernel methods of delineating home-range.

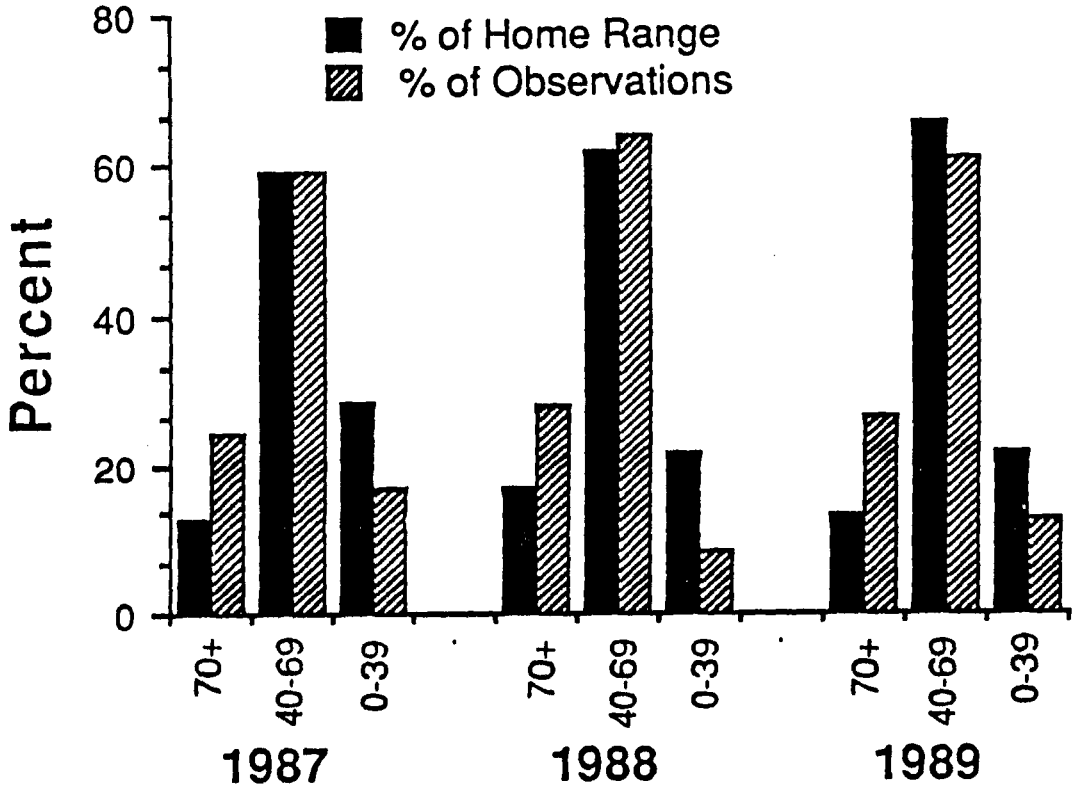


Figure 15. Graph comparing the percentage of home-range area and radio-locations by canopy closure class for birds using the coniferous forest.

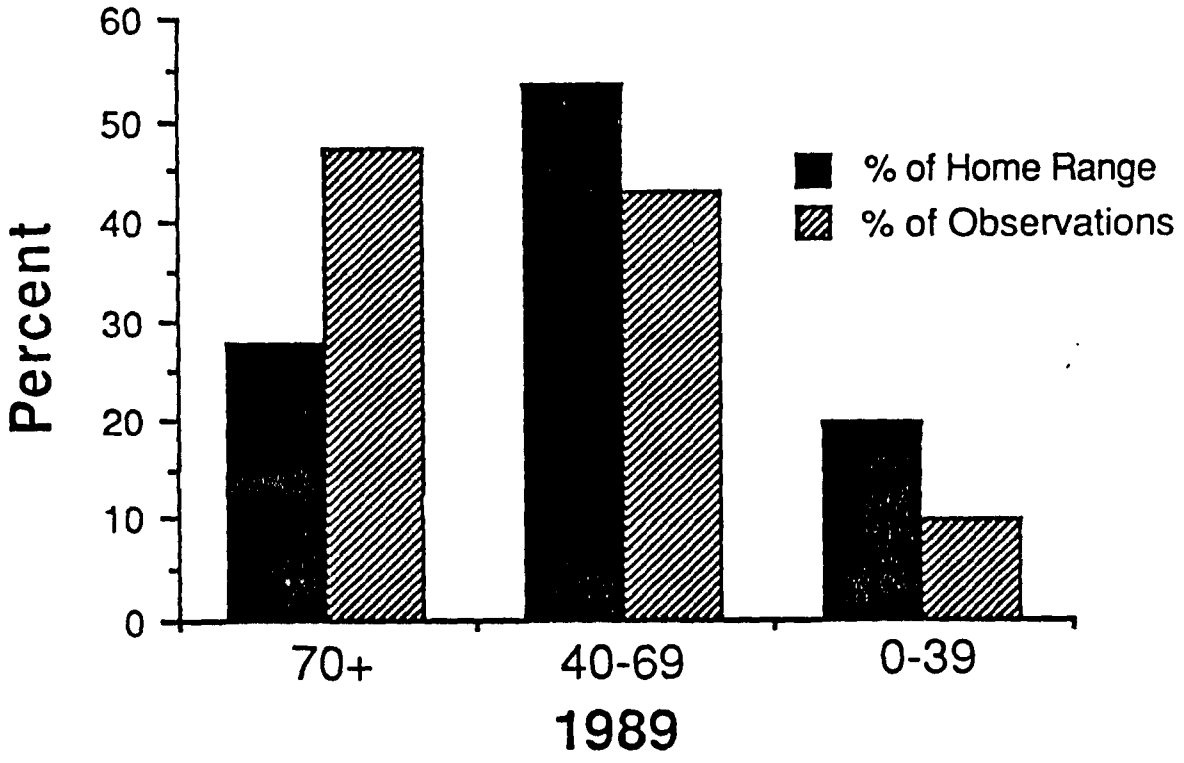


Figure 16. Graph comparing the percentage of home-range area and radio-locations by canopy closure class for birds using the oak woodland.

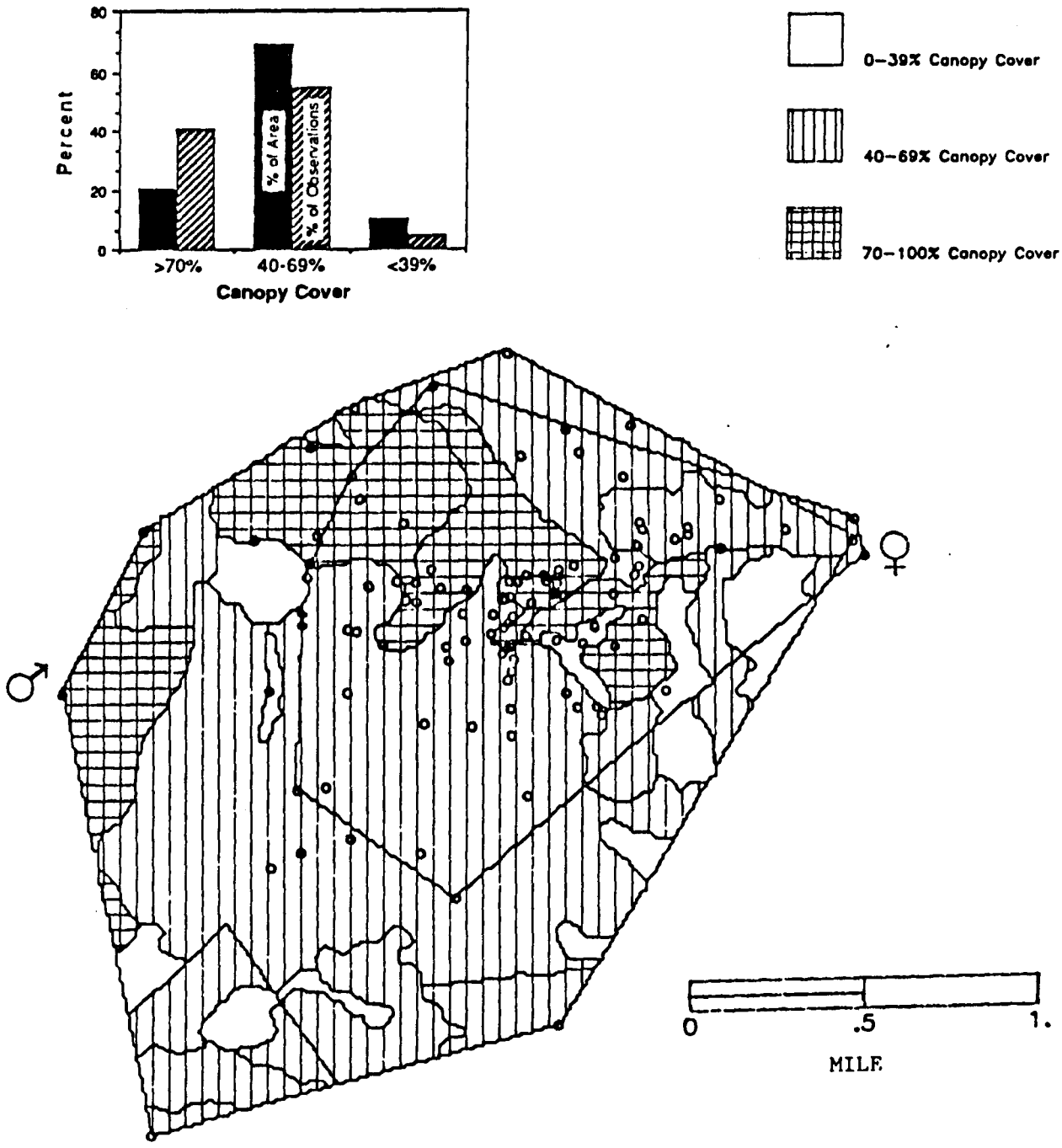


Figure 17. Map of the distribution of canopy closure classes and radio-locations for the Exchequer Creek pair.

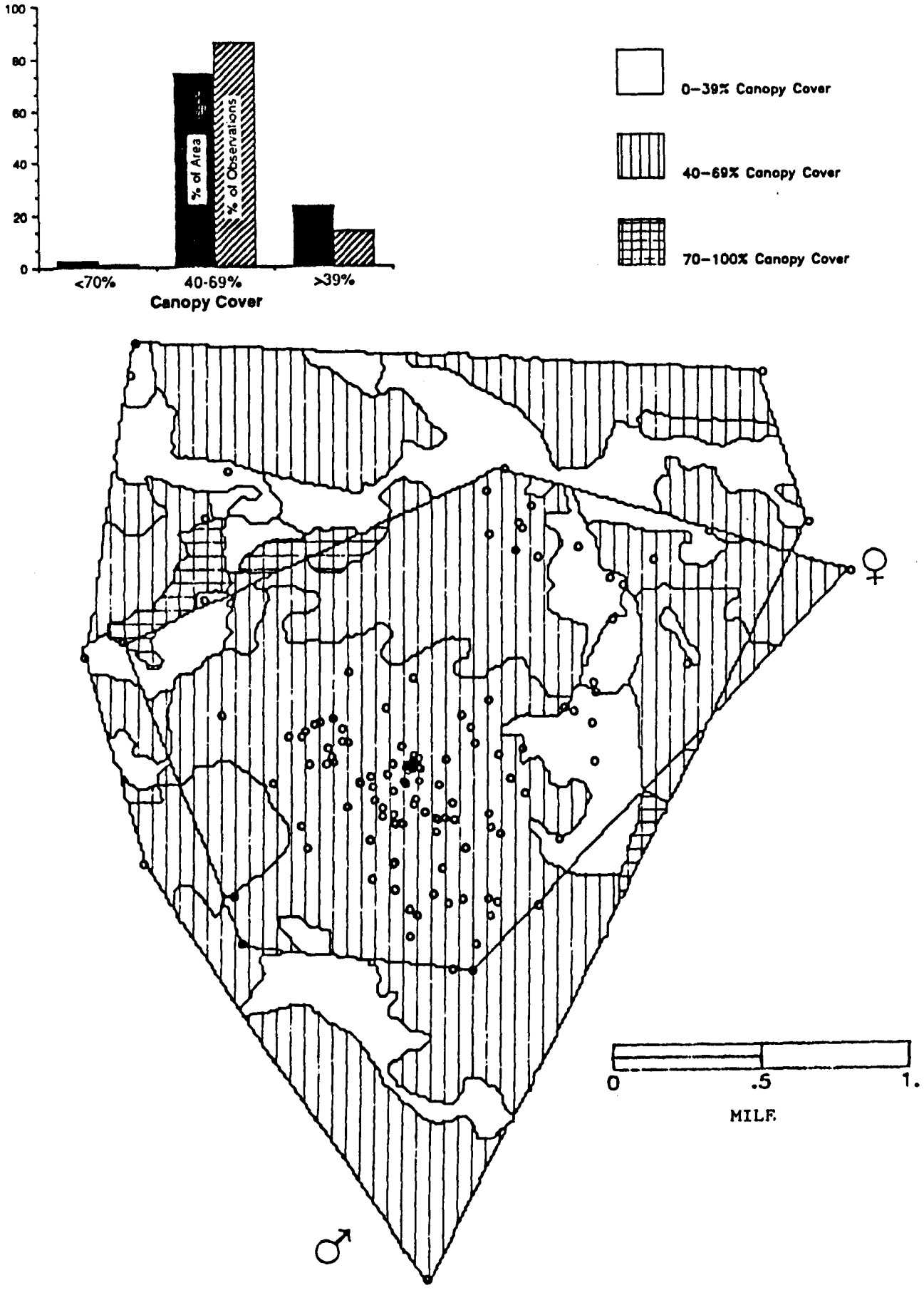


Figure 18. Map of the distribution of canopy closure classes and radio-locations for the Providence Creek pair.

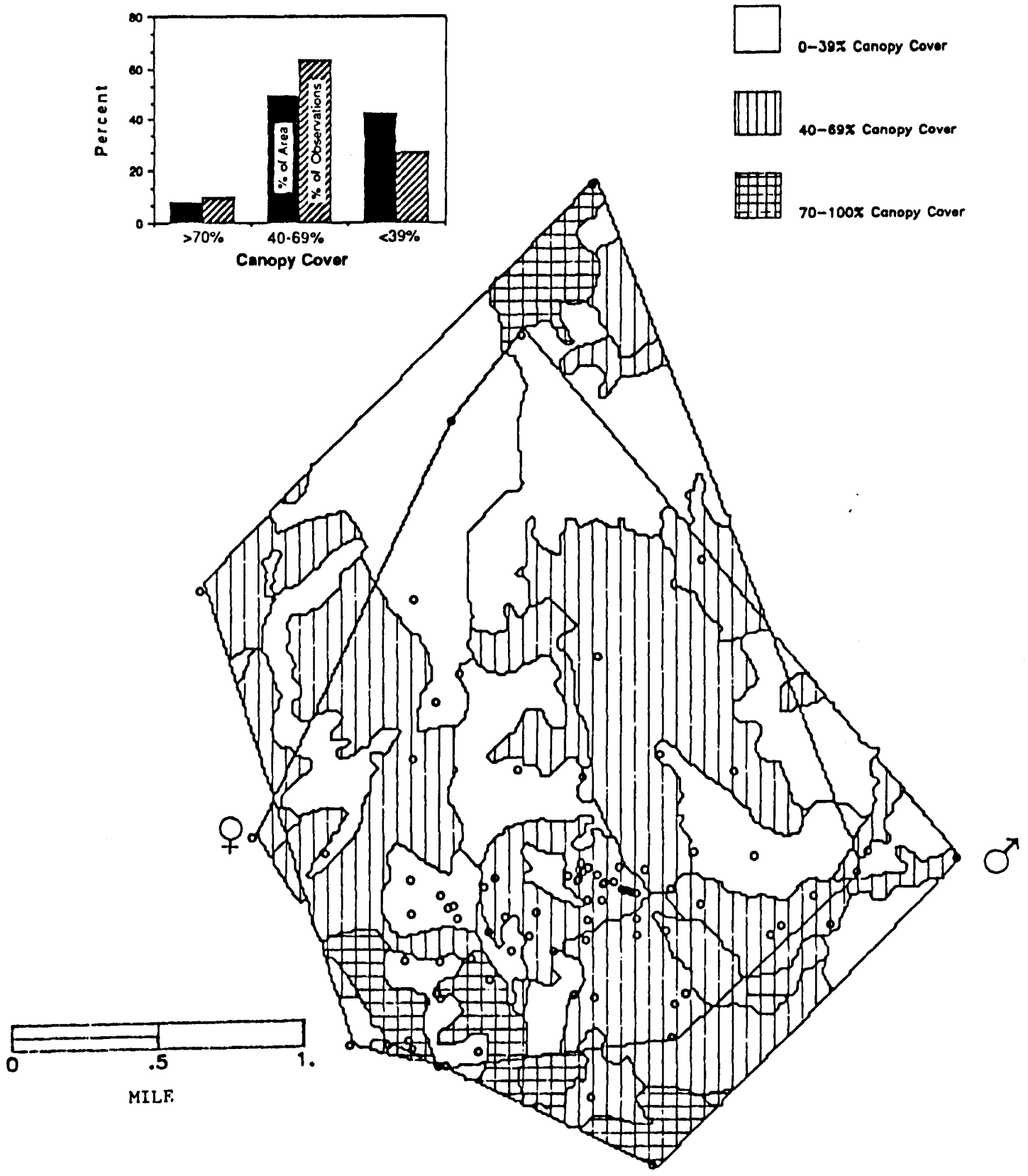


Figure 19. Map of the distribution of canopy closure classes and radio-locations for the Reese Creek pair.

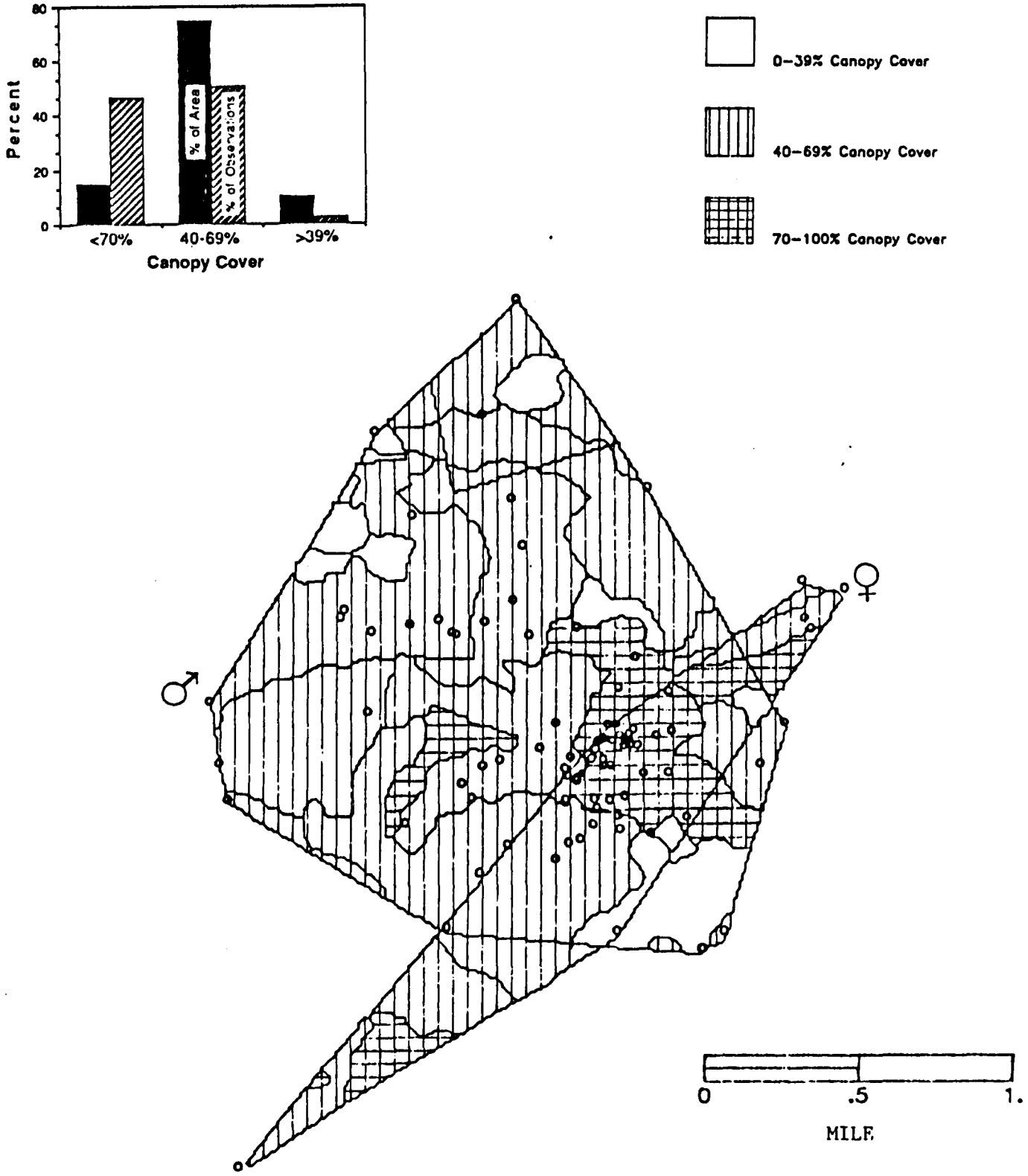


Figure 20. Map of the distribution of canopy closure classes and radio-locations for the Strawberry pair.

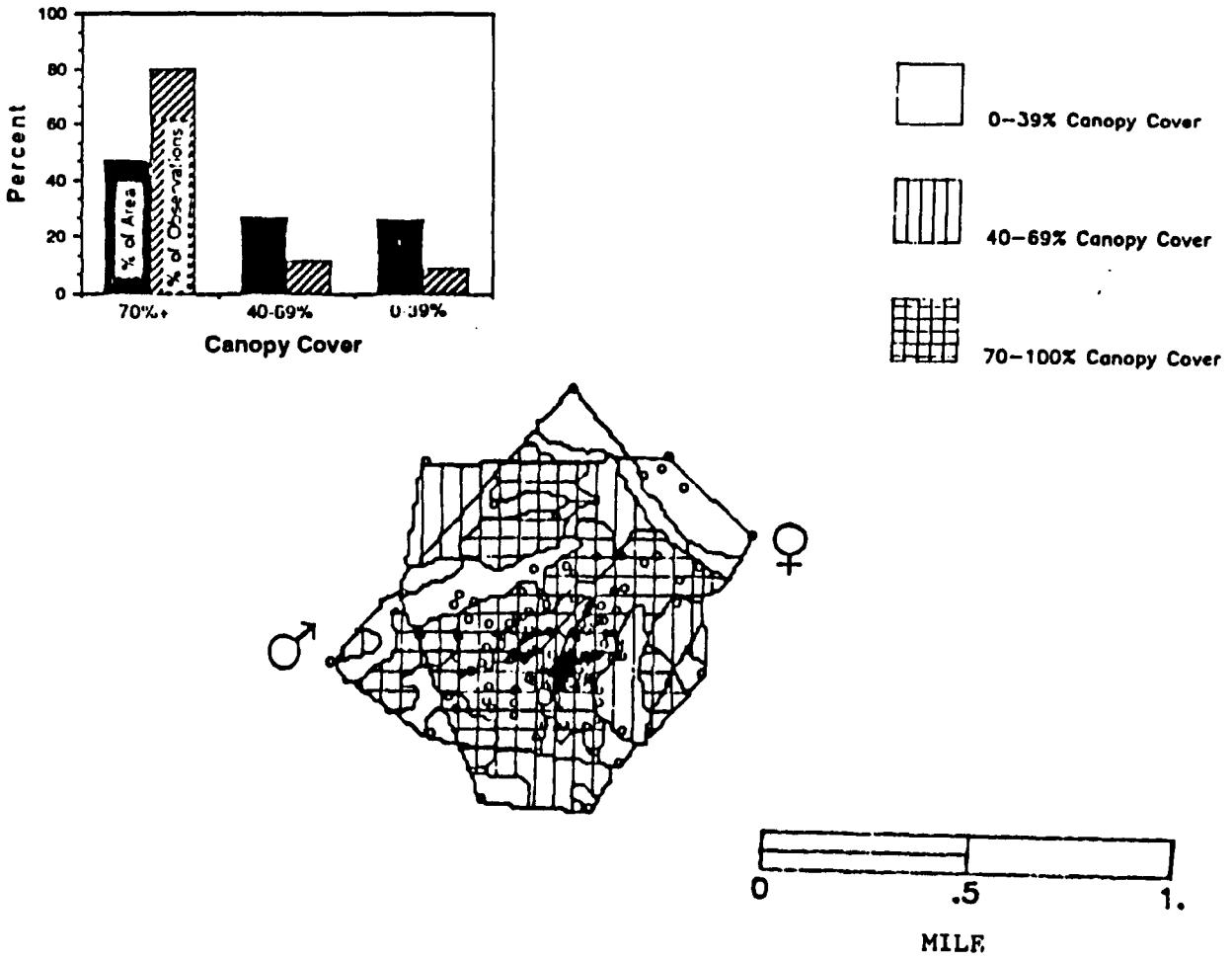


Figure 21. Map of the distribution of canopy closure classes and radio-locations for the Camp 4-1/2 pair.

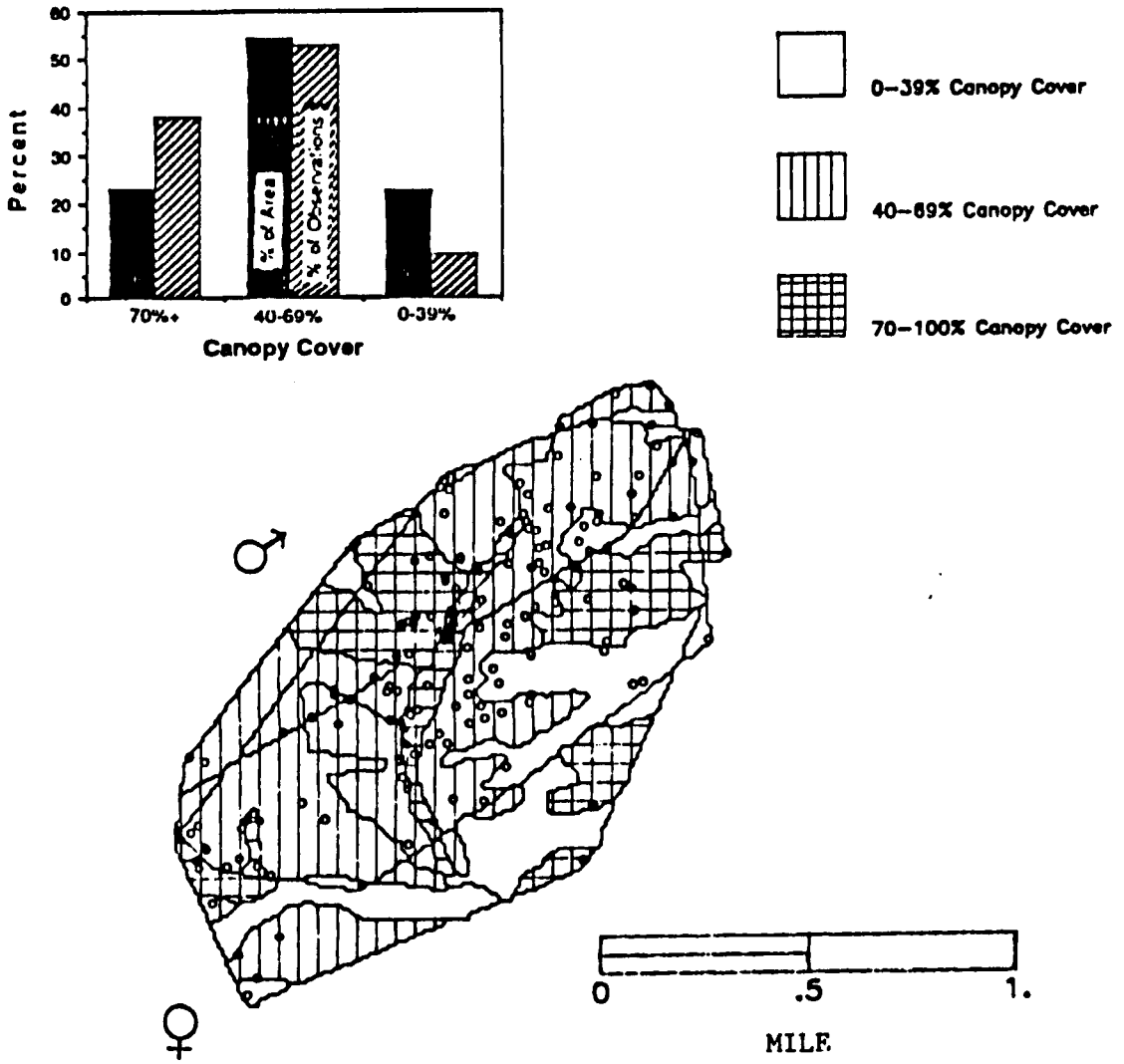


Figure 22. Map of the distribution of canopy closure classes and radio-locations for the Kirch Flat pair.

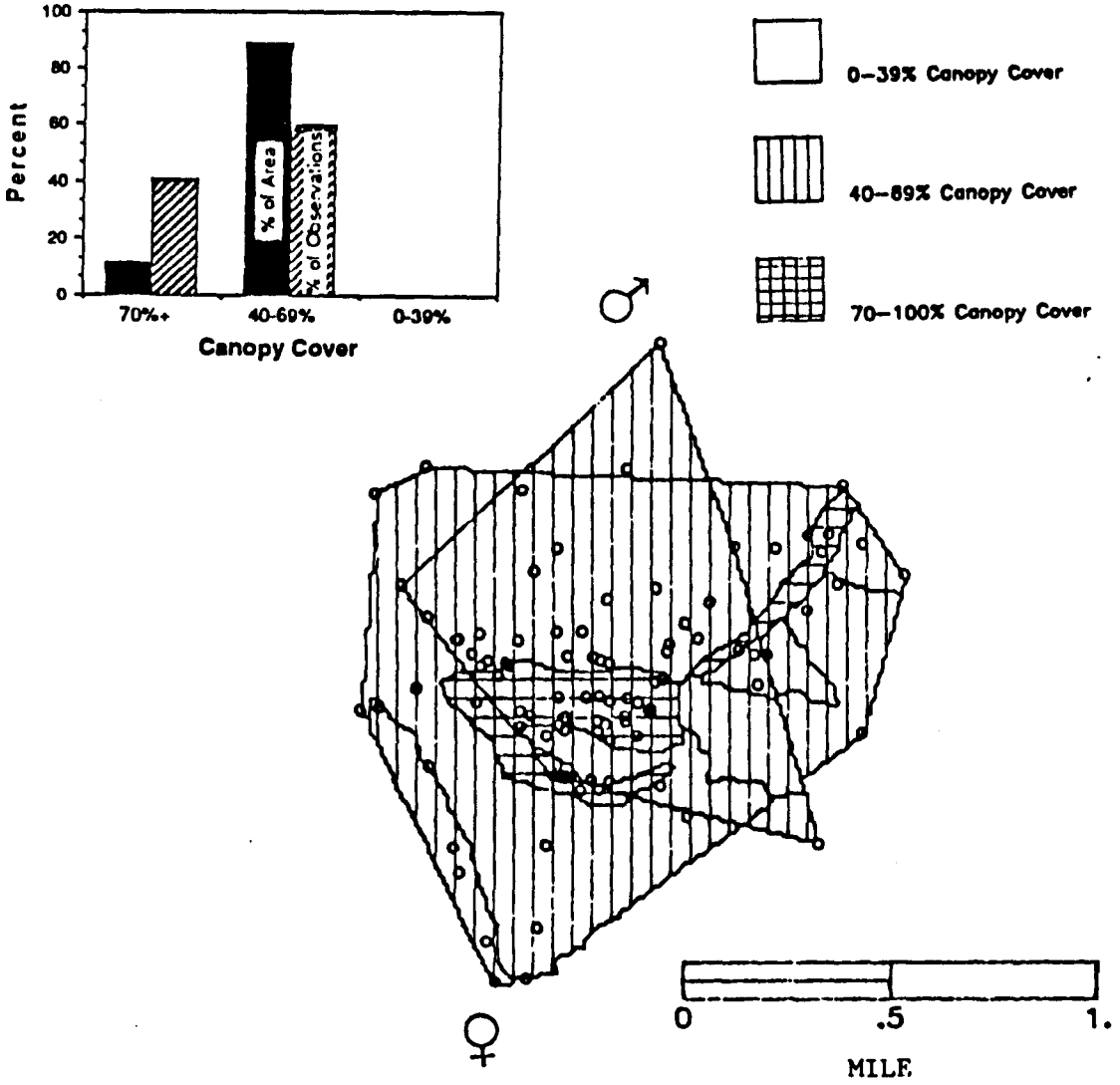


Figure 23. Map of the distribution of canopy closure classes and radio-locations for the Linda Creek pair.

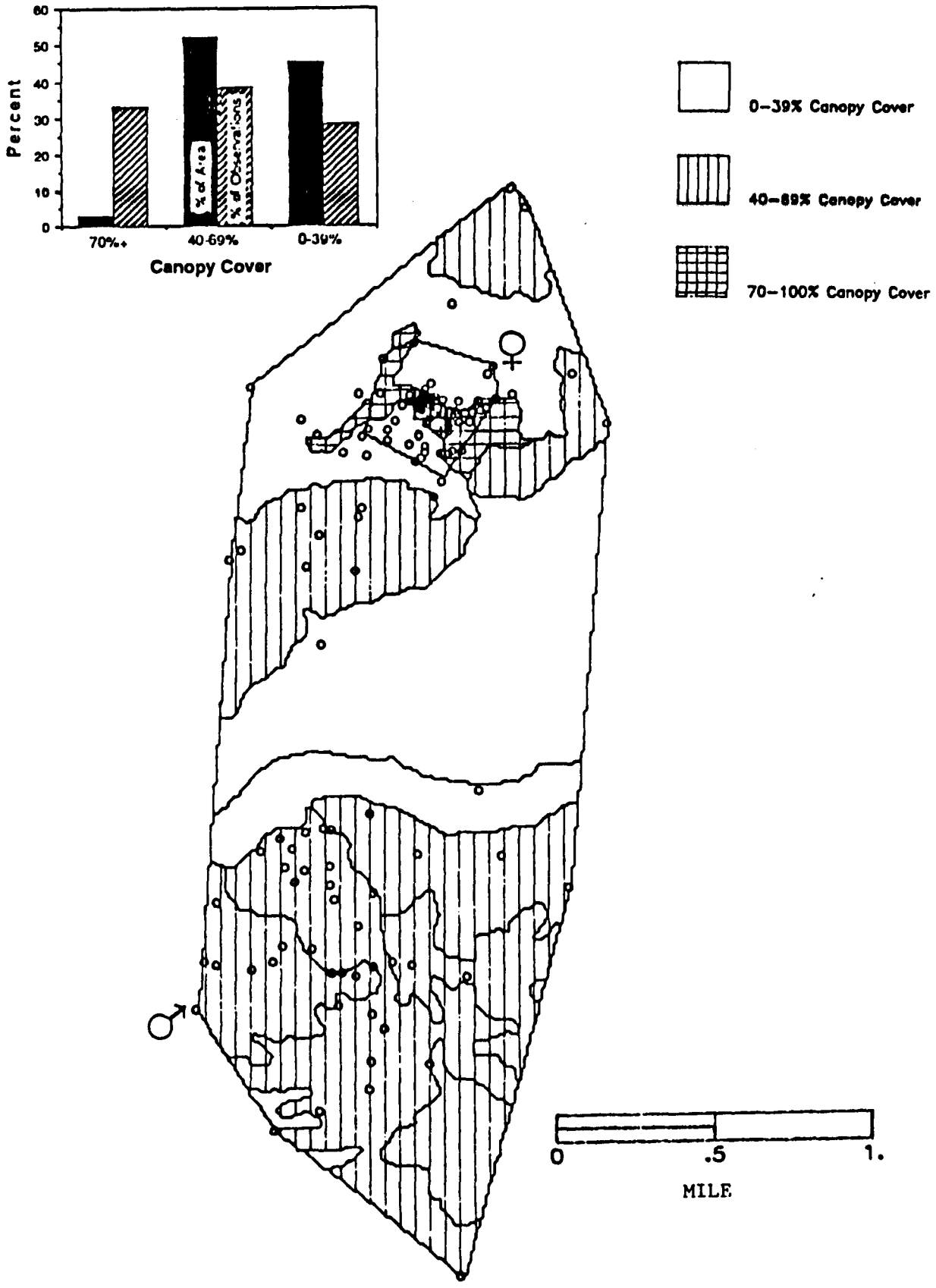


Figure 24. Map of the distribution of canopy closure classes and radio-locations for the Sacata pair.

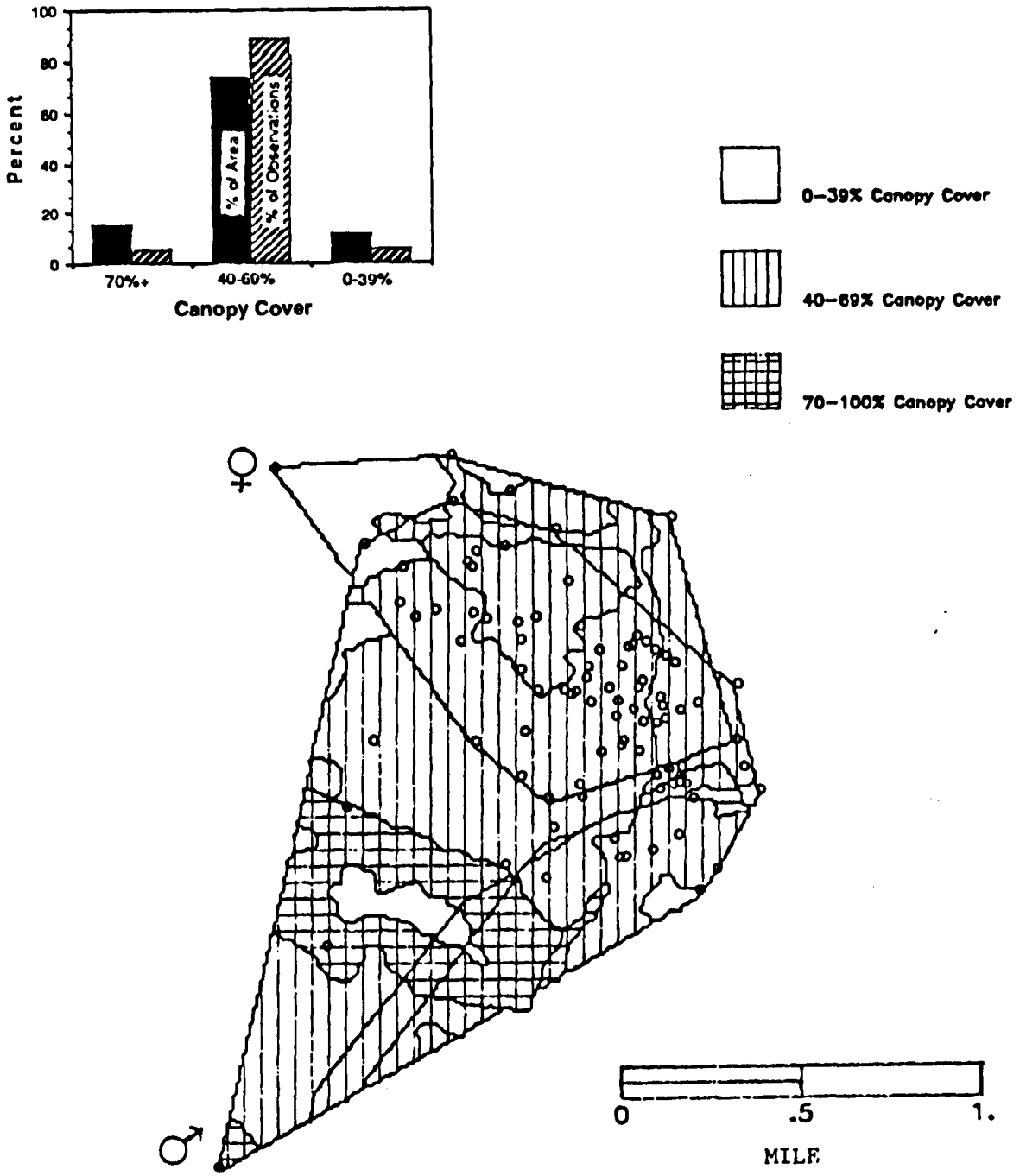


Figure 25. Map of the distribution of canopy closure classes and radio-locations for the Sycamore pair.

Table 1. Seasonal behavior category and home range size for all radio monitored spotted owls.

			Summer 1987		Winter 87/88		Summer 1988		Winter 88/89		Summer 1989	
Name	Sex	Behavior	N	Acres	N	Acres	N	Acres	N	Acres	N	Acres
OAK WOODLAND OWLS												
Camp 4 1/2	F	Resident	-	-	-	-	-	-	-	-	88	342.2
	M	Resident	-	-	-	-	-	-	-	-	122	326.9
Deep Creek	F	Resident	-	-	-	-	6	525.8	-	-	-	-
	M	Resident	-	-	3	0.0	21	54.4	4	1.0	13	19.5
Kirch Flat	F	Resident	-	-	-	-	-	-	-	-	94	704.7
	M	Resident	-	-	-	-	-	-	-	-	117	581.7
Linda Cr.	F	Resident	-	-	-	-	-	-	-	-	20	411.4
	M	Resident	-	-	-	-	-	-	-	-	82	755.6
Secata Cr.	F	Unknown	-	-	-	-	-	-	-	-	38	82.0
	M	Resident	-	-	-	-	-	-	-	-	110	1402.8
Sycamore	F	Resident	-	-	-	-	-	-	-	-	28	478.6
	M	Resident	-	-	-	-	-	-	-	-	71	1015.1
CONIFEROUS FOREST												
Bear Mdw	F	Enlarger	-	-	-	-	65	5121.6	55	4260.3	24	4108.3
Dinkey Cr.	F	Migrant	123	4516.7	-	-	-	-	-	-	-	-
	M	Unknown	29	119.8	-	-	-	-	-	-	-	-
	M2	Migrant	103	3647.4	36	8403.6	28	4605.0	-	-	-	-
Exchequer	F	Resident	101	1950.1	87	2965.7	12	1551.5	-	-	57	920.7
	M	Resident	104	2291.6	94	2292.1	3	89.2	-	-	66	2137.4
Laural Cr.	F	Resident	-	-	-	-	91	2232.8	-	-	-	-
	M	Migrant	112	2767.3	11	3989.2	-	-	-	-	-	-
	M2	Resident	-	-	-	-	116	4129.5	63	4173.8	51	1633.8
Markwood	F	Unknown	11	43.2	-	-	32	252.5	-	-	-	-
	F2	Shifter	-	-	-	-	35	989.1	24	6497.2	32	1165.1
	M	Shifter	134	1956.5	96	6176.8	3	217.2	-	-	-	-
Oak Flat	F	Unknown	-	-	-	-	-	-	-	-	20	1450.0
Providence	F	Enlarger	103	1395.1	88	7781.7	128	2112.7	55	3119.9	65	1630.1
	M	Resident	96	2367.7	68	1900.0	16	441.3	-	-	84	3241.5
Reese Cr.	F	Unknown	-	-	-	-	-	-	-	-	48	2662.7
	M	Unknown	-	-	-	-	127	2963.0	21	1485.1	56	2433.4
Stevenson	F	Migrant	37	3408.0	77	2007.2	114	5782.1	71	531.5	53	3154.5
	M	Shifter	44	1648.9	44	10373.7	26	815.7	-	-	-	-
Strawberry	F	Migrant	-	-	-	-	99	1819.1	27	292.7	29	486.3
	M	Resident	117	1569.1	94	4017.1	117	2071.7	-	-	78	1627.6

Table 2. Summer home range size (acres) for adequately sampled spotted owl pairs in the Sierra and Seqouia National Forests. Areas shown are for individual member of pair, total area used by pair, and the area shared by both members of the pair.

Pair name	Year	Sex	N	Individual Area	Paired Area	Shared Area
CONIFEROUS FOREST						
Dinkey	1987	Female	123	4517	5557	2606
		Male 2	103	3647		
Exchequer	1987	Female	101	1950	2623	1619
		Male	104	2292		
Exchequer	1989	Female	57	921	2146	911
		Male	66	2137		
Laural Creek	1988	Female	91	2233	4654	1709
		Male 2	116	4130		
Providence	1987	Female	103	1395	2788	974
		Male	96	2368		
Providence	1989	Female	65	1630	3282	1589
		Male	84	3241		
Reese Cr.	1989	Female	48	2663	3076	2020
		Male	56	2433		
Stevenson	1987	Female	37	3408	3754	1304
		Male	44	1649		
Strawberry	1988	Female	99	1819	2526	1365
		Male	117	2072		
MEAN			84	2472	3380	1566
S.D.			27	965	1106	524
OAK WOODLAND						
Camp 4 1/2	1989	Female	88	342	403	267
		Male	122	327		
Kirch Flat	1989	Female	94	705	766	521
		Male	117	582		
MEAN			105	489	585	394
S.D.			17	185	257	180

Table 3. Mortality statistics for Spotted Owls equipped with backpack-mounted transmitters.

Habitat[1]	Age[2]	Sex	Date tagged M/D/Y	No. of days before death	Weight (g) Banding	Weight (g) Death	Probable Cause of death
CF	Ad	F	4/29/87	230	641	---	Emaciation
CF	Ad	M	5/04/87	40	571	---	Unknown
CF	Ad	F	5/06/87	379 [3]	601	---	Unknown
CF	Ad	M	5/12/87	332 [4]	532	370	Emaciaton, Eye abscess
CF	Ad	F	6/04/87	844 [5]	621	---	Unknown
CF	Ad	M	6/16/87	224	522	---	Predation
OW	Ad	F	4/27/88	106	641	---	Predation
OW	Ad	F	5/16/89	36	689	---	Unknown
OW	Ad	F	5/23/89	49	635	---	Unknown

[1]CF = Conifer Forest; OW = Oak Woodland
[2]Ad = Adult: minimum of 3 yrs old based on tail shape (Forsman 1981)
[3]Died 32 days after being fitted with a new radio.
[4]Died 37 days after being fitted with a new radio.
[5]Died 90 days after being fitted with a new radio.

Table 4. Comparison of the areas of habitat types (canopy-cover classes) available with the number of locations of radio-equipped Spotted Owls in each type in home ranges of pairs in mixed-conifer forests of the western Sierra Nevada during the breeding period of 1987 (1 March through 30 September). "Overlap" includes only the area shared between home ranges of the members of a pair.

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Birds	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
Dinkey pair	463.8	56	2928.4	105	2163.1	65	8.3	24.7	52.8	46.5	38.9	28.8	81.3	<0.005
Exchequer pair	433.3	91	1758.9	103	427.7	11	16.5	44.4	67.1	50.2	16.3	5.4	119.9	<0.005
Providence pair	335.8	13	1940.0	174	515.0	12	12.0	6.5	69.5	87.5	18.5	6.0	30.8	<0.005
Stevenson pair	661.5	40	1252.5	21	1830.8	20	17.7	49.4	33.4	25.9	48.9	24.7	57.7	<0.005
Pair mean	473.7		1969.4		1233.0		13.6	31.2	55.7	52.5	30.7	16.2		
SD	136.6		701.8		892.0		4.3	19.6	16.6	25.7	15.8	12.3		
Dinkey overlap	176.9	50	1431.5	81	1006.2	48	6.8	27.9	54.7	45.2	38.5	26.8	126.0	<0.005
Exchequer overlap	348.2	90	1080.6	83	190.3	7	21.5	50.0	66.7	46.1	11.8	3.9	88.9	<0.005
Providence overlap	14.3	0	824.1	121	135.4	3	1.5	0	84.6	97.6	13.9	2.4	16.4	<0.005
Stevenson overlap	376.6	25	460.6	10	469.5	5	28.8	62.5	35.3	25.0	35.9	12.5	23.1	<0.005
Overlap mean	229.1		949.1		450.2		14.6	35.1	60.3	53.5	25.0	11.4		
SD	168.0		409.9		398.3		12.7	27.4	20.7	31.0	14.1	11.2		

Table 5. Comparison of the areas of habitat types (canopy-cover classes) available with the number of locations of radio-equipped Spotted Owls in each type in home ranges of pairs in mixed-conifer forests of the western Sierra Nevada during the breeding period of 1988 (1 March through 30 September). "Overlap" includes only the area shared between home ranges of the members of a pair.

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Birds	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
Laurel pair	744.5	13	3278.0	180	627.9	14	16.0	6.3	70.5	87.0	13.5	6.7	27.2	<0.005
Strawberry pair	427.5	67	1745.5	141	353.8	8	16.9	31.0	69.1	65.3	14.0	3.7	42.24	<0.005
Stevenson pair*	664.9	78	1836.9	43	2080.3	18	14.5	56.2	40.1	30.9	45.4	12.9	200.53	<0.005
Pair mean	612.3		2285.7		1020.5		15.8	31.2	59.9	61.1	24.3	7.8		
SD	95.1		859.9		926.6		1.2	25.0	17.2	28.3	18.3	4.7		
Laurel overlap	79.8	10	1433.4	164	197.9	7	4.6	5.5	83.8	90.2	11.6	3.9	10.6	<0.005
Strawberry overlap	239.9	62	972.8	125	153.9	3	17.6	32.6	71.2	65.8	11.2	1.6	40.96	<0.005
Stevenson overlap	198.9	64	56.3	7	67.5	1	61.6	88.9	17.5	9.7	20.9	1.4	24.3	<0.005
Overlap mean	173.0		820.4		139.9		27.9	42.3	57.5	55.4	14.5	2.3		
SD	83.3		701.8		66.5		29.9	42.5	35.2	41.4	5.5	1.4		

* The size of the Stevenson Pair's home range was determined with the removal of one observation, which nearly doubled the estimated area used.

Table 6. Comparison of the areas of habitat types (canopy-cover classes) available with the number of owl locations in each type in mixed-conifer forests of the western Sierra Nevada during the breeding period of 1989 (1 March through 30 September). "Overlap" includes only the area shared between home ranges of the members of a pair.

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Birds	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
Exchequer pair	438.1	50	1492.8	67	218.7	6	20.4	40.7	69.4	54.5	10.2	4.8	32.04	<0.005
Providence pair	90.9	1	2438.4	128	756.6	20	2.8	1.0	74.2	85.9	23.0	13.1	11.10	<0.005
Reese pair	239.7	10	1532.5	66	1312.6	28	7.8	9.6	49.7	63.5	42.5	26.9	10.35	<0.01
Strawberry pair	268.8	50	1365.7	54	186.6	3	14.8	46.7	75.0	50.5	10.2	2.8	88.38	<0.005
Pair mean	295.5		1707.2		617.8		11.5	24.5	67.1	63.6	21.5	11.9		
SD	142.3		492.7		531.3		7.7	22.6	11.8	15.8	15.3	10.9		
Exchequer overlap	256.5	43	589.6	54	72.6	5	28.1	42.2	64.0	52.9	7.9	4.9	10.22	<0.01
Providence overlap	17.8	0	1304.4	118	261.7	11	1.1	0	82.3	91.5	16.6	8.5	7.82	<0.025
Reese overlap	92.2	7	1075.6	61	860.6	24	4.5	7.6	53.0	66.3	42.4	26.1	10.87	<0.005
Strawberry overlap	109.5	46	150.7	14	34.1	2	37.2	74.2	51.3	22.6	11.5	3.2	36.32	<0.005
Overlap mean	119.1		780.8		307.4		17.7	31.0	62.6	58.3	19.6	10.7		
SD	99.8		257.0		382.0		17.7	34.2	14.3	28.7	15.6	10.5		

Table 7. Comparison of the areas of habitat types (canopy-cover classes) available with the number of owl locations in each type in mixed-conifer forests of the western Sierra Nevada during the breeding period of 1987 (1 March through 30 September).

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Bird	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
Dinkey Female	177.0	25	2278.0	55	2134.0	41	3.9	20.7	49.6	45.5	46.5	33.8	92.25	<0.005
Dinkey Male	102.0	2	2045.0	50	1278.0	26	3.0	2.6	59.7	64.1	37.3	33.3	0.62	>0.50
Exchequer Female	349.0	47	1325.0	48	275.0	3	17.9	48.0	68.0	49.0	14.1	3.0	63.34	<0.005
Exchequer Male	424.0	49	1506.0	50	380.0	5	18.4	47.1	65.2	48.1	16.5	4.8	60.03	<0.005
Laurel Male	99.0	1	1902.0	95	841.0	18	3.5	0.9	65.9	83.3	29.6	15.8	14.05	<0.005
Markwood Male	354.0	54	872.0	62	707.0	21	18.3	39.4	45.4	45.3	36.6	15.3	45.75	<0.005
Providence Female	14.0	0	1148.0	99	264.0	6	1.0	0	80.5	94.3	18.5	5.7	11.31	<0.005
Providence Male	338.0	12	1643.0	77	384.0	15	14.3	11.5	69.5	74.0	16.2	14.4	0.98	>0.50
Stevenson Female	540.0	12	1209.0	13	1623.0	13	16.0	31.6	35.8	34.2	48.1	33.3	7.25	<0.05
Stevenson Male	508.0	26	512.0	12	619.0	6	31.0	59.1	31.2	27.3	37.7	13.6	18.31	<0.005
Strawberry Male	142.0	11	1245.0	100	183.0	3	9.0	9.7	79.3	87.7	11.7	11.5	9.05	<.025
Mean	277.0		1426.0		790.0		12.4	24.6	59.2	59.3	28.4	16.8		
SD	179.0		520.0		634.0		9.2	21.4	16.6	22.6	13.5	11.6		

Table 8. Comparison of the areas of habitat types (canopy-cover classes) available with the number of owl locations in each type in mixed-conifer forests of the western Sierra Nevada during the breeding period of 1988 (1 March through 30 September).

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Bird	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
Bear Mdw Female	951.6	12	3626.4	49	558.2	4	18.5	18.5	70.6	75.4	10.9	6.1	1.56	>0.5
Laurel Female	228.7	5	1740.8	77	266.3	9	10.2	5.5	77.9	84.6	11.9	9.9	2.80	>0.5
Laurel Male	595.5	8	2970.6	103	559.7	5	14.4	6.9	72.0	88.8	13.6	4.3	16.43	<0.005
Markwood Female	249.3	22	480.0	6	263.7	7	25.1	62.9	48.4	17.1	26.5	20.0	27.37	<0.005
Providence Female	30.9	0	1583.7	126	501.6	2	1.5	0	74.8	98.4	23.7	1.5	38.39	<0.005
Reese Male	475.9	5	1695.6	103	790.0	19	16.1	3.9	57.3	81.1	26.6	15.0	30.70	<0.005
Stevenson Female	601.7	61	1570.8	35	1916.5	17	14.7	54.0	38.4	31.0	46.9	15.0	144.49	<0.005
Stevenson Male	262.7	17	322.55	8	231.3	1	32.2	65.4	39.5	30.8	28.3	3.8	14.80	<0.005
Strawberry Female	290.6	28	1274.8	65	256.0	6	15.0	28.3	70.0	65.6	14.0	6.1	16.17	<0.005
Strawberry Male	376.6	39	1443.8	76	251.8	2	18.2	33.3	69.7	65.0	12.1	1.7	25.56	<0.005
Mean	406.4		1671.0		560.0		16.6	27.9	61.9	63.8	21.4	8.3		
SD	260.0		999.0		513.0		8.2	25.2	14.9	28.0	11.4	6.4		

Table 9. Comparison of the areas of habitat types (canopy-cover classes) available with the number of owl locations in each type in mixed-conifer forests of the western Sierra Nevada during the breeding period of 1989 (1 March through 30 September).

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Bird	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
Exchequer Female	256.7	20	589.1	36	72.6	1	27.9	35.1	64.2	63.2	7.9	1.7	3.79	>0.1
Exchequer Male	438.1	30	1487.5	31	218.7	5	20.4	45.5	69.4	47.0	10.2	7.5	25.38	<0.005
Laurel Male	68.7	6	1400.8	42	161.6	3	4.2	11.8	85.9	82.3	9.9	5.9	8.17	<0.025
Providence Female	17.8	1	1345.5	55	261.9	9	1.1	1.5	82.8	84.6	16.1	13.8	0.37	>0.5
Providence Male	90.9	0	2397.6	73	756.6	11	2.8	0	73.9	86.9	23.3	13.1	8.03	<0.025
Reese Female	163.3	3	1313.8	34	1200.4	11	6.1	6.3	49.1	70.8	44.8	22.9	9.71	<0.01
Reese Male	168.5	7	1294.3	32	972.6	17	6.9	12.5	53.2	57.1	39.9	30.4	3.88	>0.1
Stevenson Female	416.4	27	1340.5	13	1399.1	13	13.2	51.0	42.5	24.5	44.3	24.5	65.84	<0.005
Strawberry Male	219.9	32	1225.4	44	183.8	2	13.5	41.0	75.2	56.4	11.3	2.6	52.95	<0.005
Strawberry Female	158.1	18	290.8	10	36.1	1	32.7	62.1	59.9	34.5	7.4	3.4	11.3	<0.005
Mean	199.9		1268.6		526.3		12.9	26.7	65.6	60.7	21.5	12.6		
SD	138.9		555.2		508.8		10.9	22.8	14.4	21.2	15.6	10.2		

Table 10. Comparison of the areas of habitat types (canopy-cover classes) available with the number of owl locations in each type in oak woodlands of the western Sierra Nevada foothills during the breeding period of 1989 (1 March through 30 September). "Overlap" includes only the area shared between home ranges of the members of a pair.

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Birds	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
Camp pair	188.2	168	106.7	24	104.5	18	47.1	80.0	26.7	11.4	26.2	8.6	91.52	<0.005
Kirch pair	176.5	80	417.1	111	174.7	20	23.0	37.9	54.3	52.6	22.7	9.5	36.81	<0.005
Secata pair	58.3	49	1088.3	57	950.3	42	2.8	33.1	51.9	38.5	45.3	28.4	506.18	<0.005
Linda pair	95.2	39	718.2	58	0	0	11.7	40.2	88.3	59.8	0	0	76.85	<0.005
Sycamore pair	177.7	5	854.4	80	130.5	5	15.3	5.6	73.5	88.8	11.2	5.6	10.98	<0.005
Pair mean	139.2		637.0		272.0		20.0	39.4	58.9	50.2	21.1	10.4		
SD	58.6		383.0		385.0		16.8	26.6	23.4	28.4	17.0	10.7		
Camp overlap	165.2	167	65.6	21	36.5	8	61.8	85.2	24.5	10.7	13.7	4.1	45.84	<0.005
Kirch overlap	117.4	71	319.3	98	81.3	8	22.6	40.1	61.6	55.4	15.8	4.5	39.41	<0.005
Secata overlap	30.3	47	0	0	52.0	30	36.8	61.0	0	0	63.2	39.0	19.46	<0.005
Linda overlap	58.8	33	296.6	33	0	0	16.5	50.0	83.5	50.0	0	0	53.66	<0.005
Sycamore overlap	0	0	327.3	64	12.9	1	0	0	96.2	98.5	3.8	1.5	0.93	>0.9
Overlap mean	74.3		201.8		36.5		27.5	47.3	53.2	42.9	19.3	9.8		
SD	66.7		156.4		32.2		23.3	31.3	40.3	39.3	25.4	16.4		

Table 11. Comparison of the areas of habitat types (canopy-cover classes) available with the number of owl locations in each type in oak woodlands of the western Sierra Nevada foothills during the breeding period of 1989 (1 March through 30 September).

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Bird	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
Camp Male	183.6	102	70.4	12	72.5	8	56.2	83.6	21.6	9.8	22.2	6.6	37.49	<0.005
Camp Female	169.8	66	101.9	12	68.4	10	49.9	75.0	30.1	13.6	20.0	11.4	22.33	<0.005
Kirch Male	132.8	39	357.1	67	91.4	11	22.9	33.3	61.4	57.3	15.7	9.4	8.84	<0.025
Kirch Female	161.1	41	379.3	44	164.3	9	22.9	43.6	53.8	46.8	23.3	9.6	26.13	<0.005
Secata Male	58.3	29	1198.3	57	950.3	24	2.6	26.4	54.3	51.8	43.3	21.8	246.72	<0.005
Secata Female	30.3	20	0	0	52.0	18	36.8	52.6	0	0	63.2	47.4	4.00	>0.1
Linda Male	95.2	30	662.4	47	0	0	12.6	39.0	87.4	61 0	0	0	48.60	<0.005
Linda Female	58.8	9	352.4	11	0	0	14.3	45.0	85.7	55.0	0	0	14.97	<0.005
Sycamore Male	177.0	5	772.0	63	68.9	3	17.4	7.0	75.8	88.7	6.8	4.3	6.65	<0.05
Sycamore Female	0	0	409.7	17	74.5	2	0	0	84.6	89.5	15.4	10.5	0.32	>0.975
Mean	106.7		430.0		154.2		23.6	40.6	55.5	47.4	21.0	12.1		
SD	67.1		365.0		283.5		18.8	26.3	30.0	31.0	19.5	13.9		

Table 12. Comparison of the areas of habitat types (canopy-cover classes) available with the number of owl locations in each type in mixed-conifer forests and oak woodlands of the western Sierra Nevada for a full year period (1 March through 1 March). "Overlap" includes only the area shared between home ranges of the members of a pair (Neal et al. 1990).

	Total areas (in acres) and numbers of observations						Percentages of areas and observations							
	Canopy cover						Canopy cover							
	70%+		40-69%		0-39%		70%+		40-69%		0-39%			
Birds	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Area	Obs	Chi-square	P
MIXED-CONIFER FORESTS														
Exch. pair (1987)	616.0	146	2428.0	239	596.0	19	16.9	36.1	66.7	59.2	16.4	4.7	125.5	<0.005
Prov. pair (1987)	1704.0	26	5142.0	317	1499.0	29	20.4	7.0	61.6	85.2	18.0	7.8	87.87	<0.005
Exch. pair (1989)	652.0	83	2276.0	135	373.0	13	19.8	35.9	69.0	58.4	11.2	5.7	40.55	<0.005
Pair mean	991.0		3282.0		823.0		19.0	26.3	65.8	67.6	15.2	6.1		
SD	618.0		1613.0		596.0		1.9	16.7	3.7	15.3	3.6	1.6		
FOOTHILL OAK WOODLANDS														
Camp. pair (1989)	222.0	283	181.0	47	270.0	26	33.0	79.5	26.9	13.2	40.1	7.3	353.41	<0.005
Kirc. pair (1989)	191.0	126	502.0	180	250.0	40	20.3	36.4	53.2	52.0	26.5	11.6	73.53	<0.005
Pair mean	206.0		342.0		260.0		26.6	57.9	40.0	32.6	33.3	9.5		
SD	21.9		227.0		14.1		8.9	30.5	18.6	27.4	9.6	3.0		
MIXED-CONIFER FORESTS														
Exch. overlap (87)	463.0	144	1943.0	217	404.0	15	16.5	38.3	69.2	57.7	14.3	4.0	143.65	<0.005
Prov. overlap (87)	221.0	19	1692.0	261	388.0	14	9.6	6.5	73.5	88.8	16.9	4.7	37.97	<0.005
Exch. overlap (89)	516.0	78	1326.0	123	151.0	9	25.9	37.1	66.5	58.6	7.6	4.3	15.26	<0.005
Overlap mean	400.0		1654.0		314.0		17.3	27.3	69.7	68.4	12.9	4.3		
SD	157.3		310.0		141.7		8.2	18.0	3.5	17.7	4.8	0.3		
FOOTHILL OAK WOODLANDS														
Camp Overlap (89)	186.0	281	74.0	43	75.0	13	55.5	83.4	22.1	12.8	22.4	3.8	112.3	<0.005
Kirc. Overlap (89)	160.0	112	354.0	145	127.0	23	25.0	40.0	55.2	51.8	19.8	8.2	44.74	<0.005
Overlap mean	173.0		214.0		101.0		40.2	61.7	38.6	32.3	21.1	6.0		
SD	18.4		198.0		36.8		21.6	30.7	23.4	27.6	1.8	3.1		